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TRANSCRIPT OF RECORD.

SUPREME COURT OF THE UNITED STATES.

No. 266.

EDWARD H. ASHCROFT, APPELLANT,

vs.

THE BOSTON AND LOWELL RAILROAD COMPANY.

APPEAL FROM THE CIRCUIT COURT OF THE UNITED STATES FOR THE DISTRICT OF MASSACHUSETTS.

FILED OCTOBER 21, 1875.

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1, 2, 3 UNITED STATES OF AMERICA,
Massachusetts District, ss:

At a circuit court of the United States for the first circuit, begun and holden at Boston, within and for the district of Massachusetts, on Wednesday, the fifteenth day of October, in the year of our Lord one thousand eight hundred and seventy-three:

Before the honorable George F. Shepley, circuit judge.

EDWARD H. ASHCROFT, COMPLAINANT,
v.
BOSTON AND LOWELL RAILROAD COMPANY, defendant. } In equity.

4 The bill of complaint in this cause was filed in the clerk's office on the fourteenth day of December, A. D. 1869, and was duly entered at the October term of this court, A. D. 1869, and is in the words and figures following, namely:

5 Circuit court of the United States, district of Massachusetts.

EDWARD H. ASHCROFT
v.
BOSTON AND LOWELL RAILROAD COMPANY. } In equity.

Bill of complaint, filed December 14, 1869.

Edward H. Ashcroft, of Lynn, in said district, brings this his bill of complaint against the Boston and Lowell Railroad Company, a corporation duly established by the laws of the commonwealth of Massachusetts, having its principal office in Boston, in said district.

And thereupon your orator complains and says that William Naylor, of the county of Middlesex, England, being the original and first inventor of a new and useful improvement in the letters patent hereinafter mentioned and fully described, the same being a new and useful improvement in steam safety-valves, which was not known before his said invention thereof, and which had not been at the time of his application for said patent in public use or on sale more than two years with his consent or allowance, on the sixteenth day of October, A. D.
6 1866, upon due application, did obtain letters patent therefor in due form of law, under the seal of the Patent Office of the United States, signed by the Secretary of the Interior and countersigned by the Commissioner of Patents of the United States, antedated January 24, 1864, whereby there was secured to him, his heirs, executors, administrators, or assigns, for the term of seventeen years from and after the date of the patent, the full and exclusive right and liberty of making, using, and vending to others to be used, the said improvement; that on the 8th day of September, 1869, the said Naylor assigned said letters patent to your orator, and that the said patent being inoperative and invalid by reason of a defective specification, through inadvertency, accident, and mistake, the same was duly surrendered, and the Commissioner of Patents, after due proceedings had, caused new letters patent, bearing date November 9, 1869, for the same invention, with amended specifications, to be issued to him for the unexpired term, as assigned, of said Naylor, as by said letters patent, in court to be produced, will fully appear.

And your orator further shows that the exclusive right and liberty

aforesaid has been and still is of great value and profit to him; yet the defendant, well knowing the premises, without consent and in violation of said letters patent and of your orator's rights, has made, sold, and used, and still does make, sell, and use, in said district, a large number of said patented improvement, but how many your orator cannot state, but prays that the defendant may discover and set forth; and thereby the defendant has infringed and still does infringe upon the exclusive rights and privileges so intended to be secured to your orator by the letters patent aforesaid.

And your orator has requested the said defendant to desist from making, using, or selling said patented improvement, and to account with and pay over to your orator the profits made by said defendant by reason of such unlawful making, using, and selling of the same.

But now so it is, may it please your honors, the said defendant wholly refuses so to do, contrary to equity and good conscience, and to the manifest wrong of your orator in the premises.

To the end, therefore, that the said defendant may if it can show why your orator should not have the relief herein prayed, and may
7 under oath, and according to its best and utmost knowledge, remembrance, information, or belief, full, true, direct, and perfect answer make to all and singular the premises, and more especially may answer, discover, and set forth the number of steam safety-valves made, sold, or used by said defendant since the date of said patent, containing said patented improvement, or any substantial part thereof;

And that the said defendant may be decreed to account for and pay over to your orator all gains and profits realized from the unlawful making, using, or selling of steam safety-valves, embracing said improvement so patented and secured to your orator as aforesaid;

And may be restrained, by an injunction to be issued out of this honorable court, from making, selling, or using any steam safety-valves embracing said improvement, or any substantial part thereof, so patented as aforesaid, and that it may be also enjoined and restrained as aforesaid during the pendency of this suit;

And for such other and further relief in the premises as the nature of the case may require and to your honors may seem meet:

May it please your honors to grant unto your orator, not only a writ of injunction conformable to the prayer of this bill, but also a writ of subpœna to be directed to the said Boston and Lowell Railroad Company, commanding it at a certain time and under a certain penalty therein to be limited, personally to be and appear before your honors and this honorable court, then and there to answer unto this bill of complaint, and to do and receive what to your honors shall seem meet in the premises.

EDWARD H. ASHCROFT.

JAMES B. ROBB, *of Counsel.*

UNITED STATES OF AMERICA,
State and District of Massachusetts:

BOSTON, *Dec.* 14, 1869.

Then personally appeared the aforesaid Edward H. Ashcroft, and made oath that the statements contained in the foregoing bill of complaint, so far as made upon his personal knowledge, are true, and so far as stated upon information he verily believes them to be true.

Before me.

JOHN G. STETSON,
Notary Public.

8 At the said October term, A. D. 1869, the following answer was filed, namely:

Answer.—Filed by consent as of February 7, 1870.

The answer of the Boston and Lowell Railroad Corporation, defendant, to the bill of complaint of Edward H. Ashcroft, complainant.

The defendant, saving and reserving to itself now and at all times hereafter all manner of benefit and advantage of exception that can or may be taken or had to the many errors, uncertainties, and insufficiencies in said bill of complaint contained, for answer thereto, for so much thereof as it is advised it is material or necessary for it to make answer unto, answering on information and belief, denies that William Naylor, of the county of Middlesex, England, was the original and first inventor of the new and useful improvements in steam safety-valves, described in the letters patent mentioned in the bill of complaint, or any of them, and denies that said improvements had not been known or used before his alleged invention thereof, and that they had not been, at the time of his application for a patent, in public use or on sale more than two years, with the consent and allowance of the patentees.

The defendant, further answering on information and belief, admits that on the sixteenth day of October, A. D. 1866, letters patent, antedated January twenty-fourth, A. D. 1864, were issued to said William Naylor, for alleged improvements in steam safety-valves, and that the said Naylor assigned said letters patent to the complainant, and that said letters patent were surrendered and new letters patent, bearing date November ninth, A. D. 1869, were issued to said complainant, as said Naylor's assignee; but this said defendant denies that said new and reissued letters patent were for the same invention described in said original letters patent, and that said original letters patent were inoperative and invalid by reason of a defective specification; and this defendant denies that said letters patent were surrendered for any justifiable cause. On the contrary, this defendant, answering on infor-

9 mation and belief, says that the said surrender was made for the purpose of procuring a reissue of said letters patent for more than said Naylor was the first inventor of, and that he did obtain such reissue, and that it was not for the same invention as was said original patent, but contained more, and more than said Naylor was the first inventor of, and that said surrender and reissue were fraudulent and void, and that neither the said Naylor nor the complainant did believe said Naylor to be the original and first inventor and discoverer of the said improvements in steam safety-valves claimed in said new and reissued letters patent, and that said Naylor and the complainant did know and believe that the same have been before known and used.

This defendant, further answering on information and belief, denies that the said invention has been and still is of great value and profit to the complainant.

This defendant, further answering, says that it has used and still uses steam safety-valves, but this defendant, answering on information and belief, denies that the same were patented to the said complainant, as stated in said bill, and the defendant denies that by using said steam safety-valves it in any way infringes or encroaches upon the rights of the complainant, as stated in his said bill; and this defendant denies that he has been requested to desist from making, using, or selling said patented improvements, and to account with and pay over to the complain-

ant the profits made by this defendant by reason of such making, using, and selling of the same.

This defendant, further answering on information and belief, says that said William Naylor was not the original and first inventor of the alleged improvements specified as his invention in said reissued letters patent, but that on the contrary thereof, long before any invention thereof by him, the same were known to and used by George W. Richardson, of Troy, county of Rensselaer, and State of New York, at said Troy, by Edwin C. Richardson, who now resides at Poultney, county of Rutland, State of Vermont, and by Marcus P. Norton, residing in said Troy, and that the same were known to and used by the said three last-named persons at said Poultney.

This defendant, answering on information and belief, says that
10 steam safety-valves, such as have been used by this defendant, and which are claimed by said complainant to be an infringement of his said reissued letters patent, were described and contained in letters patent granted by the Government of Great Britain to Thomas Green, May 9th, A. D. 1859, number 1166, and in letters patent granted unto Charles Beyer, April 25th, A. D. 1863, number 1038, and in letters patant granted by the Government of the United States to Henry Waterman, November 15th, A. D. 1853, and reissued July 9th, A. D. 1857, number 2675, and in letters patent granted by the same last-named government to George W. Richardson, September 25th, A. D. 1866, number 58294, and that the invention of said Richardson, described and contained in said last-mentioned patents, were made prior to the invention and patent of said Naylor set forth in said bill.

This defendant, further answering on information and belief, says that the said Naylor was an alien at the time his said patent was granted, as stated in said bill, and that said Naylor failed and neglected, for the space of eighteen months from the date of the patent and the granting thereof, to put and continue on sale to the public, on reasonable terms, the invention or discovery for which said patent issued.

And this defendant submits to this honorable court that the said complainant has no right to any further answer to said bill, or any part thereof, than is herein above contained, and no right to injunction, account, or any other relief prayed for in said bill, and the defendant prays to be hence dismissed with its reasonable costs and charges in this behalf most wrongfully sustained.

JOHN B. WINSLOW, *Sup't.*

UNITED STATES OF AMERICA,
State and District of Massachusetts:

FEBRUARY 10, 1870.

Personally appeared John B. Winslow, above named, and made oath that the statements of the foregoing answer by him subscribed, are true.
Before me.

JOHN G. STETSON,
Notary Public.

11 At the said October term, A. D. 1869, the following replication was filed, namely:

Replication.—Filed, by consent, as of February 7, 1870.

This repliant, saving and reserving to himself all and all manner of advantage of exceptions which may be had and taken to the manifold

errors, uncertainties, and insufficiencies of the answer of the said defendant, for replication thereunto, says that he does and will aver, maintain, and prove his said bill to be true, certain, and sufficient in the law to be answered unto by the said defendant, and that the answer of the said defendant is very uncertain, evasive, and insufficient in the law to be replied unto by this repliant; without this, that any other matter or thing in the said answer contained material or effectual in the law to be replied unto, and not herein and hereby well and sufficiently replied unto, confessed or avoided, traversed or denied, is true; all which matters and things this repliant is ready to aver, maintain, and prove, as this honorable court shall direct, and humbly prays as in his said bill he has already prayed.

JAMES B. ROBB,
For Complainant.

This cause was thence continued from term to term to the October term of this court, A. D. 1872, when the following agreement of
12 parties was filed, namely:

Circuit court of the United States, district of Massachusetts.

EDWARD H. ASHCROFT
v.
BOSTON AND LOWELL RAILROAD COMPANY. } In equity.

GEORGE W. RICHARDSON
v.
EDWARD H. ASHCROFT. }

Agreement of parties.—Filed January 3, 1873.

It is agreed that all testimony taken in either of the above suits may be used in the other of the said suits, provided that the party wishing to use such testimony in the suit other than that for which it is taken shall designate before an examiner, within the time within which such party may take testimony, what testimony he wishes so to use.

It is further agreed that in the first of the above-entitled suits complainant shall close his evidence in support of this bill on or before October 6th, 1870, and defendants their evidence in defence on or before February 3, 1873, and complainant his evidence in reply on or before March 3, 1873.

It is further agreed that in the second of said suits the complainant shall close his evidence in support of his bill on or before April 4th, 1871, and defendant his evidence in defence on or before February 3d, 1873, and complainant his evidence in reply on or before March 3d, 1873, and that rules be entered accordingly.

BENJAMIN DEAN,
Counsel for G. W. Richardson, and also Boston & Lowell Railroad Company.
JAMES B. ROBB,
For E. H. Ashcroft.

13 At the said October term, A. D. 1872, the following order of court was entered, namely:

Order of court, May 9, 1873.

LOWELL, J.:

It is ordered that four weeks be allowed to respondent to take additional evidence, subject to all objections except as to the time at which it is taken, and that two weeks thereafter be allowed to the complainant to put in evidence de bene esse in reply.

By the court.

Attest:

JOHN G. STETSON, *Clerk.*

This cause was thence continued to the May term of this court, A. D. 1873, when the following agreement of parties was filed, namely:

Agreement of parties, June 2, 1873.

By agreement before deputy clerk, the time, under order of court of May 9, 1873, is extended one week.

Attest:

EDWIN T. NASH, *Deputy Clerk.*

14 This cause was thence continued to the present October term of this court, A. D. 1873, when publication of the testimony is ordered, and the cause is set down for hearing and fully heard.

On the eighth day of May, A. D. 1874, the opinion of the court is read, and it is thereupon ordered, adjudged, and decreed that the bill of complaint in this cause be, and the same is hereby, dismissed, with costs to the respondent taxed at

From this decree the said Edward H. Ashcroft, complainant, claims an appeal to the Supreme Court of the United States, and gives good and sufficient security that he will prosecute his said appeal to effect, and said appeal is allowed accordingly.

A true record.

Attest:

JOHN G. STETSON, *Clerk.*

15 At the hearing of said cause in said circuit court the following evidence was used, namely:

EVIDENCE FOR COMPLAINANT.

Taken pursuant to the 67th rule of the Supreme Court of the United States, in equity, as amended, before me.

C. W. TUTTLE,
Examiner.

Exhibit No. 1.—C. W. Tuttle, Examiner.

UNITED STATES PATENT OFFICE.

E. H. Ashcroft, of Boston, Massachusetts, assignee of William Naylor.

Letters patent No. 58962, dated October 16, 1866; patented in England, January 21, 1864; reissue No. 3727, dated November 9, 1869. Improvement in steam safety-valves.

The schedule referred to in these letters patent, and making part of the same.

To all whom it may concern:

Be it known that I, William Naylor, of 57 Mildmay Park, in the

A 60

county of Middlesex, and kingdom of Great Britain, have invented certain new and useful improvements in safety-valves; and I hereby declare the following to be a free and clear and exact description of the same, reference being had to the accompanying drawing.

This invention relates to spring safety-valves, and is applicable to locomotive-engine boilers and stationary and marine engine boilers.

The main object to be attained by this invention is the counteracting the additional load upon the valve as it is raised from its seat, produced by the increased resistance of the spring.

This is accomplished by using a lever of the first order, one end resting, by a suitable pin, upon the safety-valve, constructed and arranged as hereinafter described, and the other end of the lever resting upon a spring; but in lieu of having this lever straight, or nearly so, I propose to bend downward that end which is acted upon by the spring, to an angle of about forty-five degrees, so that when the valve is raised by the steam, the other end of the lever is depressed upon or against the spring downward, and at the same time is moved inward toward the fulcrum, thus virtually shortening that end of the lever, and thereby counteracting the additional load upon the valve as it is raised from its seat by the greater amount of compression or tension, as the case may be, which is put upon the spring; and

My invention also consists in the valve C, constructed with projecting downward-curved lip or periphery, and in the annular chamber D, surrounding the valve-seat, whereby, as the spring is compressed by the lifting of the valve, the projecting lip of the valve and the annular recess are available in causing an increased pressure on the valve, and thus overcome the increased resistance of the spring, due to its compression, as hereinafter more fully set forth.

Figures 1 and 2 of the annexed sheet of drawings represent, respectively, a vertical section and front elevation of a safety-valve constructed according to my invention.

A is the main thoroughfare, leading directly from the boiler.

B, a lateral branch or escape-passage for a portion of the steam after it has passed the valve C.

I make this valve to project over the edges of the exit passage A, and to curve its projecting edges slightly downward, as shown in Fig. 1, so that the steam, on issuing between the valve and its seat, will impinge against the curved projecting portion of the valve, and a portion of it will be directed downward into the annular chamber D, surrounding the central passage A, and communicating with the exit-pipe B, while the other portion of the steam ascends past the edge of the valve.

E is my improved valve-lever, working on a fulcrum, F, and made to hold down the valve at one end, through the rod or spindle G, by the expansive force of the helical spring H, which exerts an upward pressure against the opposite end *a* of the lever.

This end *a* of the lever is bent downward to an angle of about forty-five degrees, and is acted upon directly by the upper end of a rod or spindle, I, situated inside the coils of the spring H, and provided with a flange or collar, *b*, against which the upper end of the spring bears, the lower end of the spring resting upon a cross-bar, K, through a hole, in the centre of which the lower end of the spindle I is guided, and is free to move vertically.

If preferred, the rod or spindle I may be dispensed with, the upper end of the spring H being turned up to bear directly against the lever, while the lower end may either lie in a sunk bed in the cross-head, or be turned down to form a contact or centre bearing-point.

Figure 3 is a detail, showing a slight modification of the mode of fitting or adapting the spring or springs H.

a is the bent end of the lever E, shown in Fig. 1.

16*a* *b* is a nipple or centre-point, which is pressed against the end *a* of the lever by one or more springs H H′.

The lower ends of these springs bear against a similar nipple or centre-point, *c*, which rests in a countersink in the cross-head K, or in the end of an adjusting-screw, *d*, passing through the cross-bar, so that by raising or lowering the screw the resistance of the spring or springs may be regulated.

L L, Fg. 2, are two long bolts, passing through corresponding sockets M M, cast on the valve-casing, and through corresponding bolt-holes, near each end of the cross-bar K, which is thus supported entirely by the two bolts.

By tightening more or less the bolts L by their nuts, the spring H may be compressed to any desired extent between the cross-bar K and the collar or flange *b*, on the spindle I.

The operation of the peculiar bent lever is as follows:

So soon as the pressure in the boiler overcomes the resistance of the spring H the valve is lifted, and a certain extra compression is put on the spring. The increasing compression of the spring during the opening of the valve has a tendency, if no compensating means are employed, to check the full opening of the valve, so as to afford an escape-orifice equal in area to that of the passage A, but, by bending down the lever, as shown at *a*, the lifting of the valve tends to draw that end of the lever toward the fulcrum, thereby virtually shortening that end of the lever; consequently, the power of the lever to compress the spring is increased in proportion as the valve is elevated, or, in other words, the resistance of the spring is proportionately diminished.

When the apparatus is properly constructed, the resistance against the lifting of the valve will be uniform, or nearly so, in whatever position the valve may be.

Figure 4 represents a vertical section of a two-inch locomotive-boiler safety-valve, wherein the spring operates by tension, in lieu of by compression, as in the previous arrangement.

The same letters of reference indicate the corresponding parts of those shown in Figs. 1 and 2.

A is the main thoroughfare from the boiler.

B is the exit-pipe for the escape-steam.

16*b* C, the valve itself, which is held by one end of the lever E, working on the fulcrum F, and bearing at one end, upon a rod or spindle, G, while its opposite end is bent downward, as shown at *a*, and is connected by the knife-edged link I with the lower end of the helical spring H, to which the link is hooked. The upper end of this spring, which is enclosed in a tubular casing, H′, is hooked into the adjustable eye R, carried by the lower end of the adjusting-screw spindle L, which passes through a central aperture in the top of the casing, and is prevented from rotating by a key fitting a slotted key-way, extending longitudinally down one side of the screw-spindle.

M is a nut or hand-wheel, working on the screw-spindle, by turning which the screw will be raised or lowered, and consequently more or less tension will be put upon the spring, and a corresponding load applied to the valve-lever E.

N is a circular knife-edged index, screwed to the top of the screw-spindle; and

O is the graduated scale, attached to the nut or hand-wheel, for indicating the load upon the valve per square inch.

The valve, on being lifted, will elevate the corresponding end of the bent lever E, and depress the opposite or bent end *a*, which will be more or less resisted by the contractile power of the spring H, but the end *a*, on being depressed, will at the same time be drawn toward the fulcrum, thereby virtually shortening that end of the lever, and compensating for the increased resistance of the spring.

When the collar of K reaches the top of the casing, no further load can be put on the valve, and thus any tampering with the valve is prevented.

Figure 5 represents a vertical section of a portion of a five-inch safety-valve, adapted for large marine or land boilers constructed according to this invention. It is similar in all essential details to the smaller arrangement illustrated at Fig. 4, and the corresponding parts are indicated by corresponding letters of reference.

In safety-valves for marine boilers I prefer, however, to close, steam-tight, the bottom of the casing containing the helical spring H by
16*c* means of a flexible diaphragm P, of vulcanized India rubber, or other suitable material capable of withstanding the action of steam, whereby all access to the spring, of salt water, thrown through the safety-valve when priming, and injurious effect thereof upon the metal, are prevented.

This diaphragm is held at its circumference between the flanges of the spring-casing and the valve-casting, while its centre is nipped between the annular end *e* of the link *i* and shoulder *f*, which shoulder has a square or hexagonal centre boss, *g*, formed thereon, and fitting a correspondingly-shaped aperture in the top of the link I.

h is nut, working on a screw in the centre of the boss *g*, and serving to nip the diaphragm between the parts *e f*.

The valve-casing is of cast iron, and the valve and seat are of gun-metal.

Q is a small relieving-lever for easing the valve when requisite, its inner end projecting beneath the end of the safety-valve lever, as shown, while its outer end is connected by a rod for actuating the relieving-lever.

Claims.

I claim—

1. The combination and arrangement, with the hereinbefo safety-valve, of bent levers of the first order, and the sprin in the manner substantially as hereinbefore set forth.

2. The safety-valve C, with its overhanging, downward-curved lip or periphery, and annular recess D, substantially as herein shown and described, and for the purpose set forth.

3. The annular recess D, surrounding the valve-seat, substantially as herein set forth.

4. The combination of the valve C and the annular recess D, as herein set forth, and for the purpose described.

W'M NAYLOR.

Witnesses:

EDWIN P. ALEXANDER,

THOS. I. BYRNE,

47 *Lincoln's Inn Fields.*

17 *Evidence for complainant.*

Taken pursuant to the 67th rule of the Supreme Court of the United States, in equity, as amended, before me.

C. W. TUTTLE, *Examiner.*

Deposition of Increase S. Hill.

OCTOBER 5, 1870.

Direct examination by James B. Robb, esq., of counsel for complainant:

Int. 1. Please state your name, age, residence, and occupation.

Ans. My name is Increase S. Hill; age, sixty-three years; reside in Boston; my occupation is United States local inspector of boilers and engines of steam-vessels, and mechanical engineer.

Int. 2. How long have you been engaged in that business?

Ans. I have been engaged as government inspector since 1852, and mechanical engineer about thirty-five years.

Int. 3. Have you examined the letters patent now shown you, being letters patent of the United States, granted to E. H. Ashcroft, plaintiff in this case, as assignee of William Naylor, for an improvement in steam safety-valves, dated November 9, 1869, being a reissue of letters patent of the United States, granted to said Naylor on the 16th of October, 1866, and antedated January 21, 1864; and are you acquainted with the steam safety-valve therein described, and do you understand the description of the same contained in the specification of said patent?

Ans. I have examined the letters patent (marked "Exhibit No. 1, C. W. T., examiner") and am acquainted with the steam safety-valve therein described as specified in said patent.

18 Int. 4. Please examine exhibit marked "No. 2," and state how it compares with safety-valves in use on the engines or boilers of the defendant corporation, as far as your knowledge extends.

Ans. It is the same.

Int. 5. Please state whether or not that exhibit is substantially the same, in its construction and mode of operation, as the safety-valve described in the plaintiff's patent.

Ans. I consider it substantially and essentially the same, differing only in depth and form of the cavity into which the steam is deflected whenever the valve is opened by the pressure of the steam in the boiler. In the defendant's valve, the steam, by the curved lip of the valve, is deflected into a semicircular annular chamber; while in the Naylor or plaintiff's valve, having the same form in every particular, the steam is deflected into a cylindrical annular chamber, producing the same effect in both cases, namely, a reflex or recoil action by the expansive and dynamic force of the steam in its exit against the curved lip of the valve, thus producing an increase of power or force to open the valve, by acting upon an enlarged area.

Cross-examination by Benjamin Dean, esq., of counsel for respondent:

Cross-int. 1. Have you examined any other letters patent of steam safety-valves than Exhibit No. 1, C. W. T., examiner? If yes, name them.

Ans. Yes, sir; I have examined other patents for safety-valves. I have not the dates of the patents. Green's patent is one; Beyer's is another; Waterman's reissue is another; Parsons' is another.

Cross-int. 2. Have you enumerated all of them?

Ans. I have, all the patent valves.

Cross-int. 3. What is the distinctive feature of Beyer's?

Ans. It differs from the Naylor or Richardson valve (the plaintiff's or defendant's) in the form of the external seat or rim round the actual seat of the valve, as this seat or rim curves downward, leaving a gradually contracted opening between the curved rim in the valve and the corresponding curved seat, the effect of which would be to
19 cause the steam to escape laterally. The apparatus to assist the closing of this valve I consider complicated and objectionable.

Cross-int. 4. Is the contracted opening between the curved rim and curved seat an objection to the Beyer valve?

Ans. I don't know as I get the meaning exactly. You ask me whether it is an objection to the valve. It may help or assist the valve in its opening.

Cross-int. 5. Does it do so, and how?

Ans. If it does, it is by the expansive action of the steam against the curved lip.

Cross-int. 6. Does it do so?

Ans. I say it may do so.

Cross-int. 7. In your opinion, would a valve constructed according to the Beyer patent do so?

Ans. Well, it may do so.

Cross-int. 8. Have you no opinion whether it would do so or not?

Ans. Not having experimented with such a valve, I hold my opinion in abeyance.

Cross-int. 9. Cannot you form an opinion from the description in the patent, without experimenting with the valve?

Ans. I prefer to form my opinion by actual experiment with the valve.

Cross-int. 10. Have you, from examining the Beyer patent, no opinion upon the matter inquired about?

Ans. No other opinion than that I have expressed.

Cross-int. 11. Was your examination of the patents you have enumerated made for the purpose of testifying as an expert in this cause, and did you take minutes from said patents?

Ans. I examined the patents for the purpose of testifying, and the minutes which I took were the record of my own impressions.

Cross-int. 12. In the Beyer patent, when the valve is raised, does not the steam impinge against an increased area?

Ans. I have answered that, I think, in a previous question, when I stated that the valve was assisted. I forget the exact form I stated it. That is all I have to answer to this question. I was in doubt
20 whether I used the word assisted, and I was inquiring of you for information.

Cross-int. 13. Is it your opinion that in the Beyer patent the raising of the valve is assisted by the increased area presented by the curved rim?

Ans. I think it may be.

Cross-int. 14. So far as that feature is concerned, is it not like the valve described in the plaintiff's patent?

Ans. It is very similar.

Cross-int. 15. Does it differ at all in the fact that the increased area assists the raising of the valve by the effect upon it of the expansive and dynamic force of the steam in its exit?

Ans. I should say it was the expansive and not the dynamic force.

Cross-int. 16. What do you mean by that answer? Please describe more in detail, the differences, in your mind, if any.

Ans. In the Naylor valve and Richardson valve, by their peculiar construction, there is a recoil action, which I term a dynamic action, to distinguish it from simple expansion. I understand here, by Naylor's and Richardson's, the plaintiff's and defendant's valve.

Cross-int. 17. Where, in the plaintiff's and defendant's valves, does the expansive force of the steam end, and the dynamic force begin to act?

Ans. I suppose the expansive force to raise the valve-ends at the periphery of the rim of the valve; and the dynamic power would begin and end with the recoil action.

Cross-int. 18. By the outer rim of the valve, do you mean the outer rim of that which rises and falls, or the outer rim of the valve-seat?

Ans. I am speaking of the valve and not the seat.

Cross-int. 19. If the dynamic power begins with the recoil action, how does it assist in or operate in raising the valve?

Ans. Because it impinges against the curved lip of the valve.

Cross-int. 20. If the expansive force continues to the periphery of the rim of the valve, as you have said in your 16th inswer, what surface is there left for the dynamic force to act upon?

21 Ans. The dynamic force can act simultaneously on the same part of the valve that the expansive force acts upon, towards raising the valve, namely, the rim upon the valve—the curved rim on the valve, I should say.

Cross-int. 21. When does what you call the dynamic force first begin to operate?

Ans. When it reacts from the point or base to which it is deflected by the curved rim upon the valve.

Cross-int. 22. Does it not begin to operate before that?

Ans. I do not see that it can exist before that, to any appreciable extent, in this valve.

Cross-int. 23. Do you know of any valve in which it does?

Ans. No, sir; I don't remember any.

Cross-int. 24. What do you consider the essential feature of the Naylor patent?

Ans. I consider the overhanging lip of the valve and the cylindrical annular chamber to be the essential features.

Cross-int. 25. What constitutes the annular chamber?

Ans. In the Naylor valve it is that cavity into which the steam is discharged when the valve is opened.

Cross-int. 26. Why do you call it annular?

Ans. Because it is in the form of a ring.

Cross-int. 27. Any space between the valve and an outer pipe, enclosing the same, is an annular space, such as you mean, is it not? I mean, when both pipe and valve are circular.

Ans. There are two spaces involved in a question like that, and I don't know to which you refer. There may be a horizontal space and a vertical space.

Cross-int. 28. How are two spaces involved in that question?

Ans. If the valve is situated above the pipe or above the top of the pipe, then there would be a horizontal space below the valve.

Cross-int. 29. What do you mean by the pipe, in your last answer?

Ans. The pipe you imagine to be around the valve, if I got your question right.

Cross-int. 30. The 27th question speaks of a pipe enclosing the
22 valve, and of course surrounding it. Now please answer the said question.

Ans. If the pipe is as high or higher than the valve itself, then there would be a vertical annular chamber.

Cross-int. 31. Is that the kind of annular chamber of which you have spoken as essential to the Naylor patent?

Ans. It may be slightly modified from that and still have the same effect upon the valve.

Cross-int. 32. Question repeated.

Ans. Yes, with the modifications I have last named.

Cross-int. 33. Is every chamber, such as described in your answer to the 30th interrogatory, such an annular chamber as you understand to be called for by the Naylor patent?

Ans. I conceive a chamber to be called for by the Naylor patent which would, in effect, be equivalent to the one he describes and claims.

Cross-int. 34. Question repeated.

Ans. I conceive a chamber is called for and is necessary to produce the effect upon the valve which he claims.

Cross-int. 35. Question repeated.

Ans. I do not see that I can make the statement more definite. It is absolutely essential that a chamber of some kind or form should be under the valve—I mean annular chamber. If you have no objection, I should like to alter the phraseology. I want to alter it in this way: I mean, an annular chamber, erasing the words "of some kind or form."

Cross-int. 36. Is every chamber of a round form, around the outer periphery of the valve, and extending above the outer periphery of the valve, within what you understand the Naylor patent calls for?

Ans. Every chamber of a circular form around the valve, as you describe, is called for by the Naylor patent.

Cross-int. 37. Is every such chamber within the Naylor patent, as you understand it?

Ans. I conceive that such chamber is necessary, but may be variously modified so as to retain all the essential features claimed by Naylor.

23 Cross-int. 38. The question is not whether such a chamber may be modified so as to retain all the essential features claimed by Naylor, but whether you understand that every such chamber is within his patent.

Ans. I understand that every chamber which has an annular recess is within his patent.

Cross-int. 39. Would the depth of such chamber make any difference, in your opinion?

Ans. Not unless it was less than semicircular, and even then the valve would work very well—instead of very well, I mean quite well.

Cross-int. 40. Has not the Beyer patent, of October 21, 1863, such a chamber?

Ans. No, sir.

Cross-int. 41. Have you the Beyer patent in your hand, and will you describe the essential differences between the chamber of said patent and the chamber of the Naylor patent?

Ans. I have the Beyer patent in my hands. The chamber of Beyer's patent, in the first place, is stopped up on top, so that no steam can escape upward by the valve, but is thrown obliquely against the sides of the chamber, by the peculiar form of the lip of the seat of the valve.

The effect of the steam, in issuing from the valve, cannot have the same effect upon the valve that the Naylor patent has.

Cross-int. 42. Have not both the Beyer and Naylor patents overhanging lips, for the purpose of turning the steam downwards into the chamber?

Ans. Yes, sir.

Cross-int. 43. Are not the chambers of both annular?

Ans. Yes.

Cross int. 44. Has not the Beyer patent a curved lip upon the valve, which turns the steam downward into the annular chamber?

Ans. It has.

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Cross-int. 45. Is there not an increased or larger area in the Beyer patent, outside the valve-seat, for the purpose of assisting in
24 raising the valve to a greater extent than the valve would be raised without said increased area?

Ans. Yes, sir.

Cross-int. 46. Is the annular chamber of the Naylor or plaintiff's patent open at both top and bottom?

Ans. It is open at the top but not at the bottom.

Cross-int. 47. Look at Exhibit 1, C. W. T., Examiner, which is the reissue to E. H. Ashcroft of the Naylor patent, and then say whether the annular chamber is not open at the bottom for the escape of steam.

Ans. It is open at the side.

Cross-int. 48. How far below the downward lip or outer periphery of the valve is the bottom of said annular chamber in said exhibit?

Ans. The larger part of the bottom of the annular chamber is but a short distance from the lip of the valve, as shown in the drawing, and the balance of it is farther down.

Cross-int. 49. Please explain your answer more fully.

Ans. I can only explain it by a drawing or by a model made for that purpose.

Cross-int. 50. Are not all parts of the bottom of said annular chamber equally distant from the lip of the valve?

Ans. No, sir.

Cross-int. 51. With the drawings of Exhibit 1 in your hands, and which are in the case, please state, with proper references thereto, what parts of the bottom of said chamber are nearest the lip of the valve, and what parts most distant.

Ans. That part marked "D" is nearest the lip of the valve; and that part marked "B," or the outlet, is the farthest off—I should say, the horizontal outlet, because there are two outlets.

Cross-int. 52. What seperates those two parts of the annular chamber from each other?

Ans. The partition, which is shown in the drawing.

Cross-int. 53. How much of the space of said annular chamber does said partition occupy?

Ans. Without a model before me I cannot tell.

25 Cross-int. 54. Is there any division of said annular chamber into two parts? Is there any partition dividing said chamber?

Ans. The drawings seem to show such a division. I cannot tell by the drawing how far it is divided, having no model to illustrate the drawing.

Cross-int. 55. How does the steam get from one part of the annular chamber to the other?

Ans. As the lower part of the annular chamber, as shown in the drawing, is so drawn, I infer that the orifice B may be made to communicate

with one side of the annular chamber marked "D." I may be mistaken from the character of the drawing, having no model to verify it.

Cross-int. 56. Is that all the answer you can give to the last interrogatory?

Ans. Yes.

Cross-int. 57. Is there any way whereby you can see how the steam gets from one part of the annular chamber to the other?

Ans. I infer from the drawing that the exit-orifice, marked "B," communicates with that part of the chamber marked "D."

Cross-int. 58. What leads you to such inference?

Ans. The drawing.

Cross-int. 59. What in said drawing?

Ans. If the drawings marked "Fig 1" represent a section cut through the centre, it would appear that the annular chamber marked "D" is intended to represent a communication between the said chamber, marked "D," and the exit-pipe, marked "B," as said communication is expressed in the description given in the letters patent.

Cross-int. 60. Is what you take, in said drawing, to be a partition between the chamber D and the lower part which connects with exit-pipe B that part between said upper chamber and said lower part which is made dark, or covered by parallel lines?

Ans. That is the part I take to be the partition.

Cross-int. 61. Does said part, shaded by parallel lines, mean anything more than thin feathers to connect the inner and outer cylinders?

Ans. They may be feathers, or that partition may extend round
26 to the point of opening of the horizontal orifice; but, in the absence of a model, I cannot tell which it is, as there are no drawings of the plan of that part of the valve.

Cross-int. 62. Is it not manifest that they are feathers, because of the part not shaded on the opposite side of exit-pipe A from exit-pipe B?

Ans. Not necessarily.

Cross-int. 63. Would it make any difference, in your opinion, as to the operation of said valve described in said patent, whether said shaded parts are feathers, or a partition extending round to the point of opening of the horizontal orifice?

Ans. No, sir; it would make no difference; for I know this valve would operate equally well if the orifice B was stopped up entirely, and this from actual experiment.

Cross-int 64. Have you ever experimented with a valve having an annular chamber like the one in the drawings, said annular chamber connecting at its side, below the valve, with an exit like exit B?

Ans. Yes, sir.

Cross-int. 65. When and for what purpose?

Ans. Sept. 12, 1870, and for the purpose of comparing this valve with a variety of other valves.

Cross-int. 66. Where now is said valve?

Ans. I do not know.

Cross-int. 67. What became of it?

Ans. I do not know.

Cross-int. 68. Into whose possession did it go from yours?

Ans. M'r Ashcroft's.

Cross-int. 69. When?

Ans. At the date named.

Cross-int. 70. How long was it in your possession?

Ans. Half a day.

Cross-int. 71. Did you observe its construction?

Ans. I did.

Cross-int. 72. Was there a partition between the upper part of the annular chamber and the lower, which lower was connected with an exit like exit B in the drawings?

27 Ans. There was no partition, but there were brackets connecting the inner and outer cylinder.

Cross-int. 73. Was the annular chamber in said valve open between the cylinders from the lip of the valve to the bottom of the exit corresponding with exit B?

Ans. Yes.

Cross-int. 74. What was the distance between the lip of said valve and the bottom of the annular chamber?

Ans. I did not measure it, but it may have been about four inches.

Cross-int. 75. What was the distance between the two cylinders?

Ans. I did not measure that. From recollection it may have been from half to five-eighths of an inch.

Cross-int. 76. What was the diameter of exit corresponding to exit B?

Ans. I did not measure it; but, from the best of my recollection, it may have been from two to two and a half inches.

Cross-int. 77. Did you experiment at the same time with a valve like Exhibit 2?

Ans. I did.

Cross-int. 78. How did the size of the exit in said valve, corresponding with exit B, in the drawing, compare in size with the exit to the valve, corresponding with exit A, in the drawing? I now refer to the valve inquired about in interrogatories 64 to 76, inclusive, the Naylor valve, we will call it.

Ans. The size or openings were all alike, excepting the orifice, B, I did not measure. I mean, by all alike, the valves in both cases were of the same size; consequently, the cylinders in which the valves set were of the same size. The diameter of exit A I measured; it was two and a quarter inches. The diameter of exit B I did not measure; but, as I said before, it was from two and a quarter to two and a half inches in diameter.

Cross-int. 79. Is there no difference, in your opinion, between the effect upon the valve of an annular cylindrical chamber, like that which you have described as the Naylor valve, and like that in Exhibit 2?

28 Ans. There is very little difference in the effect, and what there is, in my opinion, is decidedly in favor of the Naylor valve.

Cross-int. 80. What do you mean by the words "in favor of the Naylor valve"?

Ans. I mean that the Naylor valve, in my opinion, is better in its operation than the other.

Cross-int. 81. In what respects?

Ans. While it relieves the boiler equally well, it opens and closes without making a sudden and loud report.

Cross-int. 82. Is the suddenness and loudness of the report the only difference?

Ans. No. The Naylor valve closes at or nearly at the pressure at which it opens, while Exhibit 2 does not close until the pressure falls in the boiler from two to four pounds below that at which it opens.

Cross-int. 83. Is this opinion, and the others you have given, formed from experiments made by you, to enable you to testify in this case, or are they the results of reasoning on your part?

Ans. What do you mean by others?

Cross-int. 84. I mean, more particularly, your answer to the 5th direct interrogatory.

Ans. They are the result of actual experiments made by me.

Cross-int. 85. In the experiments you made with the Naylor valve, and the valve like Exhibit 2, did you use two separate valves?

Ans. Yes, sir. I used one of each upon the same boiler, alternately, and under the same circumstances.

Cross-int. 86. Were the valves both of the same construction, excepting only the construction of the annular chambers?

Ans. The Naylor valve was constructed, as near as possible, according to the drawing in the patent, and the valve like Exhibit 2 was constructed as that is, as near as possible.

Cross-int. 87. Question repeated.

Ans. I don't know as I can answer that any differently from what I have.

Cross-int. 88. Do you understand the 86th interrogatory?

Ans. I think I do.

29 Cross-int. 89. Please state whether there was any difference in the construction of said valves, other than that, in one the annular chamber described in the Naylor patent was around the valve, and in the other an annular chamber like that in Exhibit 2 was around the valve.

Ans. The Naylor valve was like that described in the plaintiff's patent, having an annular chamber substantially as therein described; and that like Exhibit 2 had an annular semi circular chamber.

Cross-int. 90. Was there any difference between them other than the difference in their annular chambers?

Ans. Nothing essentially.

Cross-int. 91. What difference was there that you did not consider essential?

Ans. Well, a trifle in the weight, or an hundredth part of an inch in its diameter, or any similar trifle.

Cross-int. 92. Did you try both valves in the chamber of the Naylor patent?

Ans. No.

Cross-int. 93. Might not the difference in the closing of said valves, of which you have testified, be caused by some trifling difference in the valve other than in the structure of the annular chambers?

Ans. No, sir.

Cross-int. 94. How do you know?

Ans. That is my opinion.

Cross-int. 95. Did the Naylor valve with which you experimented have on it the lever described in the Naylor patent?

Ans. No, sir.

Cross-int. 96. Who made the two valves with which you experimented?

Ans. I do not know, positively.

Cross-int. 97. Who furnished them to you?

Ans. M'r Ashcroft.

Cross-int. 98. Did you ever see any other Naylor valve except the one with which you experimented?

Ans. No, sir.

30 Cross int. 99. Did you ever know of the existence of any other one?

Ans. Yes.

Cross-int. 100. How many others?

Ans. Four or five or six, of different kinds.

Cross-int. 101. Did you ever know of the existence of any other Naylor valve except the one with which you experimented?

Ans. No, sir; I never saw any other.

Direct examination resumed:

Int. 6. How does the cross-bar, spring and stem, now shown you, and marked "Exhibit 3," compare with the device for loading the valve, used by you in the experiments, before referred to in the preceding cross-interrogatories?

Ans. It is identically the same so far as it goes; it needs the two standard bolts and nuts to screw down the spring upon the valve.

Int. 7. How did the lip of the "Naylor valve," with which you experimented, compare with the lip of the valve shown in Fig. 1 of the drawings annexed to the plaintiff's patent?

Ans. It was like it.

INCREASE S. HILL.

31 *Evidence for respondent.*

Taken pursuant to the 67th rule of the Supreme Court of the United States, in equity, as amended, before me.

C. W. TUTTLE, *Examiner.*

Deposition of William C. Hibbard.

TUESDAY, *April* 25, 1871.

Direct examination by Benjamin Dean, esq., of counsel for respondent.

Int. 1. State your name, age, residence, and occupation.

Ans. My name is William C. Hibbard; age, fifty-six years; reside in West Roxbury, Mass., and do business in Boston, as a mechanical engineer.

Int. 2. What has been your experience as a mechanical engineer, and have you had any experience, and what, as an expert in patent causes?

Ans. I have during the whole working portion of my life been engaged in the construction and designing and superintending the construction of machinery, and especially steam-engines and steam machinery; and for about twenty years past have, from time to time, testified as an expert in mechanics, in the trial of patent suits.

Int. 3. Have you examined letters patent of the United States to E. H. Ashcroft, assignee of William Naylor, being a reissue, No. 3727, dated Nov. 9, 1869, of letters patent to William Naylor, No. 58962, dated Oct. 15, 1866, being plaintiff's Exhibit 1, in this case; and
32 do you understand the construction and mode of operation of the valve therein described?

Ans. I have examined the patent mentioned, and believe I fully understand the construction and mode of operation of the mechanism therein described.

Int. 4. Have you examined Exhibit No. 2, C. W. T., Examiner, in this case; and do you understand its construction and the mode of operation of its mechanism?

Ans. I have examined the exhibit, and understand its construction and mode of operation.

Int. 5. Is said exhibit, its construction or mode of operation, substantially similar to that described in said Exhibit 1, or otherwise? and give your reasons for your opinion.

Ans. The valves mentioned in the interrogatory are, in my judgment, substantially different in construction and mode of operation, and in the principles upon which they respectively act. The mechanism described in the Naylor patent relates to two peculiarities in the construction of the mechanism. The first relates to the manner of applying the spring to the valve through a peculiar arrangement of a lever, and which, as I understand, is not involved in this controversy. The other part of the invention relates to the peculiar construction of the valve itself, whereby an increased pressure is designed to be produced upon the valve, when the valve has opened and allowed the steam to escape, for the purpose of overcoming the increased resistance of the spring due to its compression by the opening of the valve. This consists in forming upon the valve a concave lip which extends some distance beyond the outside of the joint of the valve, and projects downward, so that when the steam escapes from the seat of the valve, it will impinge against this concave surface and be deflected downward into an annular space which surrounds the main opening of the valve, in the valve-casing, and from which the steam is led away through a branch pipe. It appears to have been the intention of the inventor to use the impact of the issuing steam upon the concave lip of the valve to assist in lifting it, and this alone; the annular chamber, surrounding the main opening, and into which the steam is discharged when it leaves the valve,
33 serving no other purpose than that of a conduit for the steam.

The Richardson valve, Exhibit 2, also has what may be called a lip, outside of the valve-seat, which projects downwards, and nearly comes in contact with the outer portion of the valve-seat, or the piece of metal in which the seat is formed, leaving an annular open space between the ground joint of the valve and the stricture or narrow space formed by the outer edge of the lip and that of the valve-seat. The operation of this valve is this, namely: that when the valve opens, the steam expands and flows into the annular space around the ground joint. Its free escape is prevented by the stricture before mentioned, requiring a considerable pressure to force the escaping steam through it; and this force acts upon the area of the valve outside of the ground joint, and adds so much to the force tending to open the valve and compress the spring which holds the valve closed. This amount can be graduated or determined by the joint action of the area, which is added to the valve outside of the ground joint, and within the edge of the lip at the point where it approaches the outer edge of the seat most nearly, and the width of the opening which is left between the lip and the seat, which determines the freedom of escape of the steam from the annular space, and consequently the pressure of the steam within that space; thus it is seen that the additional pressure exerted on the valve, to open it, is due to the elastic pressure of the steam, and not to the impact of the steam upon the lip. By reason of this construction, the operation of the valve in overcoming the increased resistance of the spring is very efficient, and prevents the pressure of the steam in the boiler from exceeding that required for opening the valve. This mode of operation is not, in any degree, to be found in the Naylor valve. The steam, escaping from this valve, simply impinges against the concave surface of the lip, and is deflected downward by it into the annular space around the valve; and as the weight of the steam escaping is so exceedingly small, its momentum, so far as it is expended upon the interior of the lip, is also exceedingly small, and by no means sufficient to produce the result, or, in other words, the additional pressure upon the valve that is required to overcome the increasing resistance of the spring, due

34 to the rising of the valve, to open it. There is nothing about the construction of this valve to prevent the free escape of the steam into the atmosphere, after it has left the ground joint of the valve; and therefore no such pressure of the steam can be produced upon the lip as is produced by the obstruction of the free passage of the steam by a stricture, as is the case in the Richardson valve, and to which, entirely, in my judgment, the Richardson valve owes its efficiency.

The views that I have expressed in relation to the Naylor valve do not rest in mere opinion alone, but have been verified by me by experiments; and in practice the Naylor valve does not, so far as its opening and closing are concerned, operate materially different, in this respect, from the common safety-valve, showing that the lip alone cannot produce the result which is produced by the Richardson valve, in relation to the matters before mentioned in this comparison.

Int. 6. You say that the annular space in the Naylor valve serves only as a conduit to take off the steam; does all the steam escaping from the valve pass through said conduit? Explain its mode of operation in this respect.

Ans. It does; it not only directs all the steam downwards, but, also, a strong current of air downward through the space between the valve and the valve-casing, or the outer boundary of the annular space, mentioned in my previous answer. This annular current passing downward around and upon the outside of the valve, has the effect to impose upon the valve an additional pressure of the external air beyond the atmospheric pressure; and, in my judgment, would nearly overcome or counterbalance any upward pressure that would be exerted by the escaping steam upon the under side of the lip. The intensity of the current of air downward, past the outer edge of the lip, into the annular space, shows that the steam must have produced a partial vacuum in that annular space; and for that reason, also, measurably counteracts the effect of the impact of the escaping steam upon the lip in its tendency to open the valve, or to exert an upward pressure upon it.

Int. 7. What becomes of the steam in the Richardson valve after it has passed the outer lip of the valve? Explain its mode of operation in this respect.

35 Ans. In the Richardson valve, in the form in which it is shown in the patent of Richardson, the steam escapes outward with a downward inclination into the open air. In the Richardson valve, Exhibit 2, there is added outside of the stricture and the lip, and below it, a recess, having a curved bottom, which receives the steam from the stricture and deflects it upwards, so that the steam escapes from that recess in an upward direction. The only operation which this addition is to perform is to prevent the steam escaping laterally in all directions, which would produce an annoyance, which is prevented by directing it upwards within an appropriate conductor; but this does not, in my judgment, affect the distinctive mode of operation of the valve which I have before stated. The only effect which it appears to me it can have as regards raising the valve, is this, that throwing an annular sheet of steam upward carries the enclosed air upward with it, and cutting off the access of the surrounding air tends to make a partial vacuum above the valve, which, so far as it amounts to anything, would relieve so much atmospheric pressure on the valve, and by that amount tend to open the valve; but this is something entirely distinct from the direct pressure of the steam upon the annular space or area of the valve, within the stricture, and outside of the ground joint, which I have before explained.

Int. 8. Please look at Exhibit 1, in the drawings of the Naylor patent,

and state where is the bottom of the annular chamber or passage in said drawing; and whether there is anything, and what, separating the part marked "D" from the part marked "B" that you can discover.

Ans. The bottom of the chamber D is even with the bottom of the passage B, and the parts marked as in section between B and D are radial bars, with passages between them, allowing free passage from the upper to the lower parts of the chamber. This is shown clearly in certain views in plan, in the English patent of Naylor, for the same thing, which are here omitted (the last sentence of witness' answer is objected to as manifestly incompetent), and which clearly show how this part of the valve-casing is constructed. It is also shown in Fig. 1 by the dotted lines upon the part of the drawing marked as in sec-
36 tion, which shows that there is open space beyond the part marked in section; and it is also required by the description which says that the steam which is directed downward into the annular chamber D communicates with the exit-pipe B, to do which there must be an open passage downward.

Int. 9. Look at the patent to Charles Beyer, No. 1038, sealed Oct. 16, 1863, marked "Defendant's Exhibit A, C. W. T., Examiner," and state whether you find thereine ither, and which, of the peculiarities of the Naylor patent, Exhibit 1, C. W. T., Examiner; and, if yes, state which of said peculiarities you find there.

Ans. I have examined the Beyer patent, and find that it describes a safety-valve, which has attached to the valve, outside of the ground joint, a curved lip projecting downward, which directs the steam downward into an annular space surrounding the central passage in which the valve works; from which annular space the steam is led outward, horizontally, by a branch pipe marked *e*, leading from one side of the annular space even with the bottom, or nearly so.

Int. 10. State whether or not, in said Beyer patent, the curved lip, by its increased area, assists in raising the valve.

Ans. From the fact that there is used, in connection with this curved lip, also a projecting portion on the valve-seat, which approaches the lip more nearly at the outer part than near the ground joint, they would have, to some extent, I think, the operation produced by the stricture in the Richardson valve; probably not to the same extent, but the steam within that space would, I think, have an appreciable action in raising the valve. So far as merely directing the steam downward into an annular space is concerned, I do not see that it would operate materially different from the Naylor valve.

Int. 11. Look at the certified copy of the English patent to Thomas Green, filed Nov. 9, 1859, and marked "Defendant's Exhibit B, C. W. T., Examiner," and state whether you find therein either, and which, of the two peculiarities of Exhibit 1, about which you have testified.

Ans. I do not find either of them; but find that the mode of operation of the valve is, in some respects, more nearly approximating the Rich-
ardson valve; that is, the use of an annular space outside of the
37 ground joint, and outside of which space is an opening in the form of a stricture, which would have the effect to give an increased area upon which the steam acts by its pressure after it has passed the ground joint, and thus aids in opening the valve; but this surface is not curved downward, and is not so placed in relation to the ground joint that the steam would impinge against it so as to act in any degree by its momentum.

Int. 12. Look at the English patent to William Naylor, dated January 18, 1864, being "Defendant's Exhibit C, C. W. T., Examiner," and

state whether that is the patent to which you have heretofore referred in one of your answers.

Ans. It is; and the figures I referred to in a previous answer were 2 and 6.

(Defendant's counsel now offers in evidence Exhibit C, heretofore referred to.

Complainant's counsel objects to it as immaterial and irrelevant.

Defendant's counsel here puts in evidence Exhibits A and B, heretofore referred to, and also a certified copy of letters patent to Henry Waterman, dated Nov. 18, 1853, for an improvement in safety-valves for locomotive engines, No. 10243, marked "Exhibit D, C. W. T., Examiner"; also, a certified copy of reissue of said letters patent, said reissue bearing date July 9, 1867, and No. 2675, marked "Exhibit E, C. W. T., Examiner"; also, a certified copy of letters patent to George W. Richardson, dated September 25, 1866, and No. 58294, and marked "Exhibit F, C. W. T., Examiner."

Complainant's counsel objects to the reissued patent to Henry Waterman as immaterial.)

Int. 13. Look at Exhibit D, No. 10243, to Henry Waterman, and state whether you find therein either, and which, of said two peculiarities in the Naylor or Ashcroft patent, marked "Exhibit 1, C. W. T., Examiner."

(Objected to as immaterial.)

Ans. I do not find in Exhibit D either of the peculiarities which are before mentioned, and which are described in the specification of Exhibit 1, being the reissue of the Naylor patent to Ashcroft.

38 Int. 14. Look at Exhibit D, No. 10243, patent to Henry Waterman, and also at Exhibit F, patent to Geo. W. Richardson, and state whether you find described there either the valve described in Exhibit 1, or a valve like Exhibit 2.

Ans. I do not find in either of them the valve described in Exhibit 1, or any valve constructed or operating on the same principle; but do find, in Exhibit 2, a valve constructed and operating precisely upon the principle of the valve shown and described in the patent granted to Richardson, Exhibit F, and also substantially the same as the valve shown in the patent granted to Henry Waterman, Exhibit D, under a somewhat different form of construction, but embodying the same principle and mode of operation.

Int. 15. Where do you find said principle and mode of operation in the Waterman patent?

Ans. I find, in the drawings of the Waterman patent, that the safety-valve therein represented, in connection with other devices, has a construction that clearly embodies the principle and mode of operation to which I have referred in my previous answer.

WEDNESDAY, *April* 26, 1871.

Int. 16. Look at Exhibit G, C. W. T., Examiner, and state what it is, and whether you have witnessed any experiments with it, in its present condition; and, if yes, state where, and on what kind of an engine said experiments were tried, and with what care.

Ans. Exhibit G represents the internal structure of the Naylor valve, so far as relates to the form of the valve, and of the interior of the casing in which it is placed. The lip upon the valve is made detached so that it can be removed for the purpose of showing how the valve works, in practice, both with the lip and without it. The arrangement of the spring for holding the valve upon the seat is the same that is usually employed for that purpose with the Richardson valve. This valve was

placed on the boiler of a locomotive, in one of the engine-houses of the defendant corporation, at East Cambridge, and steam was got up in the boiler to about a hundred pounds to a square inch. The experiments which we tried with the valve were observed with much care by myself, with others, and the minutes which I then took were from my
39 personal observation. One or more of the experiments were made with the valve in the condition the valve is now in, with the curved lip upon it.

Int. 17. Please state fully the results of those experiments.

Ans. The steam commeneed to blow off at about one hundred pounds, commencing to blow gradually, with the steam rising and the discharge from the valve increasing, until it reached one hundred and sixteen pounds, at which pressure the steam was turned into the tender, when the pressure began to fall, until it reached a hundred pounds, when the valve closed, operating in the same way, apparently, that the common safety-valve would operate under similar conditions. The steam all passed downward into the annular space around the central opening of the valve, and was discharged from the tin pipe at the side, and there appeared to be a strong current of air flowing downward, past the valve into the annular chamber, which was indicated clearly by holding bits of paper a little above the valve, an inch or an inch and a half, or so, which were drawn in past the valve with great velocity, and instantly appeared outside with the escaping steam, showing that the steam in escaping from the lip of the valve downward into the annular space produced a considerable vacuum around the valve. From this it appears to me, conclusively, that the curved lip upon the valve does not, to any appreciable extent, aid the valve in opening by means of the steam discharged at any given pressure, so as to prevent the pressure of the steam increasing materially above that point, which I understand to be the purpose of the devices described in the Naylor reissue.

Int. 18. Did any steam escape above the valve?

Ans. None whatever.

Int. 19. Were any experiments tried with said exhibit, the curved lip being off; and, if yes, with what results?

Ans. There was one of which I took particular note. The steam commenced to blow off at one hundred pounds, and gradually rose to one hundred and twelve, the discharge increasing at the same time. At this pressure the steam was turned into the tender, when the pressure gradually decreased till it reached ninety-eight or ninety-nine
40 pounds, at which the valve closed. The valve, in this condition, was simply a common safety-valve, with the steam discharging in an outward direction into the annular space within the casing around the valve, some of the steam escaping through the tin pipe. The valve in this case, as in the other, exhibited the action of the ordinary safety-valve, and did not appear to be materially influenced in its action, as compared with the previous experiment by the absence of the curved lip; that is, so far as regulating the discharge of the steam from the boiler was concerned.

Int. 20. Look at Exhibits H^1 and H^2, C. W. T., Examiner, and state what they are, and whether at about the same time and upon the same engine you witnessed any experiments with said valve, and state the results of said experiments.

Ans. Exhibit H^1 represents the Richardson safety-valve, with the valve and seat substantially as shown and described in Richardson's patent, No. 58294. The ring H^2 is made to slip on to the outside of the valve-seat H^1, to form a cup-like recess, into which the steam is dis-

charged after it leaves the stricture between the lip and valve-seat, for the purpose of directing the current of steam upward. Several experiments were tried, both with Exhibit H^2, around the valve-seat, and also with it off and in the condition in which it now is. And when the cup H^2 was used it was placed at two different heights, at one time resting on the iron, and at another raised about 3-16th of an inch above it. The results of the experiments were, that in the last-named condition the blowing off of the steam commenced at ninety-five pounds, and the valve shut at eighty-eight pounds. With the cup down upon the iron the valve commenced to discharge at ninety-six pounds and shut at eighty-eight pounds. With Exhibit H^2 removed, that is, in the condition in which it now is, it commenced to discharge at ninety-nine pounds and shut at ninety-four; and, repeating the experiment, it discharged at ninety-eight pounds and closed at ninety-three. But in neither of these experiments did the pressure of the steam rise above the point at which the valve commenced to discharge; and the valve also discharged all the steam that the boiler generated. These experiments were all made during the same day, and upon the same boiler, and under substantially the same conditions of firing; and these, in connection with
41 other experiments, were made as rapidly in succession as the valves could be removed from, and connected with, the boiler.

Int. 21. How happened it that the valve last testified about should commence discharging at ninety-five or ninety-six pounds, with the cup H^2 on, and at ninety-nine and ninety-eight pounds with it off?

Ans. I attributed the difference to this, that in taking the cup H^2 off from Exhibit H^1 we were obliged to remove the valve-spring and the cross-bar above it, and, after removing the cup, replace them; and probably the spring was screwed down a little harder when it was replaced than it was before, which would require a higher pressure of the steam to raise the valve. The spring is so stiff that a very little difference in the distance at which the valve is screwed down makes a considerable difference in the pressure of the spring on the valve.

Int. 22. Could the presence or absence of the cup have any effect upon the pressure at which the valve would commence discharging?

Ans. It would not.

Int. 23. Did you, on the same day, witness the trial of any other Richardson valve than Exhibit H? And, if yes, state the result of said experiment, and to what engine it was attached.

Ans. I examined a Richardson valve attached to another engine, which engine had its steam up, or nearly so. The fire was started up and steam raised until it blew off from the valve at a pressure of one hundred and sixteen pounds by the *guage*. The steam did not rise any higher than the pressure at which it blew off, and the valve closed at a pressure between one and two pounds less than that.

Int. 24. Had said valve the cup attached to it?

Ans. I cannot now remember whether I looked to see or not.

Int. 25. Why should there be such a difference between different Richardson valves in the amount of pressure at closing, less than the amount of pressure at opening?

Ans. It is due, probably, to the difference in the capacity of the strictures; a less capacity at the stricture will cause the valve to be kept
42 open to a lower pressure of the steam than if the stricture is greater within certain working limits; that is, so that the stricture shall not be of so great capacity as to prevent the pressure of the steam from accumulating in the annular space between it and the ground joint.

Int. 26. Is the capacity of said stricture in the Richardson valve easily

adjustable for the purpose of regulating the pressure at which it is desired it should close?

Ans. It is in the manufacture of the valve.

Int. 27. Look at Exhibit 1, C. W. T., Examiner, and state what it is, and whether you have witnessed any experiments with said valve, when, and the results.

Ans. Exhibit 1 is one of the valves with which experiments were tried on the occasion of trying the other experiments before referred to. It is a valve with the co-operating faces of the valve and seat fitted up in the manner shown in the Waterman patent, Exhibit D, C. W. T., Examiner. In this case, the form of the valve and seat are somewhat different from the forms employed by Richardson, and in which the stricture or the point at which the valve and seat approach each other. In several experiments with this valve the blowing-off pressure was ninety-five pounds and the shutting pressure ninety-two pounds; and in no case did the pressure rise higher than the pressure before mentioned at which the steam blew off.

Int. 28. Is the amount of pressure at which the Richardson valve will blow off adjustable, or is it capable of being regulated and controlled; and, if yes, by what means?

Ans. It is, by compressing the spring more or less, by screwing down the nuts on top of the cross-bar above the spring, by which any desired pressure can be put upon the valve.

Cross-examination by J. B. Robb, esq., of counsel for complainant:

Cross-int. 1. In making the comparisons you have given in your answer to direct interrogatory 3, you assumed, did you not, that Exhibit G correctly represents the Naylor valve, and that Exhibit 2 is made in uniformity with the Richardson patent?

Ans. I assumed that in Exhibit G the valve and its seat, and the interior of the valve-casing which enclose them, was like the Naylor
43 patent. I did not assume that the arrangement of the spring for producing pressure on the valve was like that shown in that patent. Also, in relation to Exhibit 2, the valve seat shown in the Richardson patent does not have a cup attached to it; but it does, in my opinion, operate in the same way as the stricture shown in the Richardson patent, so far as the opening and closing of the valve by the pressure of the steam is concerned.

Cross-int. 2. In Exhibit 2, does not the steam begin to escape when the valve is raised above the ground joint?

Ans. It does.

Cross-int. 3. Does it not impinge upon a curved lip, or downward curved lip, or periphery, or curved projecting portion of the valve?

Ans. It does.

Cross-int. 4. It is not thereby directed downward?

Ans. I think not. Its operation, as I understand it, is, that the steam, when it escapes from the ground joint, expands into the annular space between the valve and seat within the stricture, and loses its character of a defined current; and when it escapes from the stricture it takes a direction due to the form and position of the surfaces from between which the steam emerges; this is in a downward direction; but not for the reason, in my judgment, that the curved lip attached to the valve projects downward, and thereby merely deflects the current of the steam issuing from the ground joint.

Cross-int. 5. You don't understand, then, that the steam, after issuing

from the ground joint of Exhibit 2, is deflected by impinging against the curved lip, do you?

Ans. I do not, if I understand the question; because that part of the surface of the curved lip which is in a line with the surface of the ground joint is nearly or about at a right angle with that line. The steam escapes downward, in my opinion, not because of the form of the interior of the lip, which is in a line with a ground joint, but because the form of the outlet of the steam from that space which I have before called the stricture. The steam would issue in the same direction, whatever might be the form of other parts of the annular space, so long as it had sufficient capacity for the steam to expand in it.

44 Cross int. 6. In point of fact, however, is not the direction of the escaping steam downward?

A. It is.

Cross-int. 7. What is the size of the opening in Exhibit 2, which you call the stricture, when the valve is closed?

Ans. From the form of the parts, I cannot see; but as near as I can judge, measuring in a rough way, I should think it to be three or four hundredths of an inch.

Cross-int. 8. Suppose it to be one-sixteenth of an inch, and suppose the valve to be raised one thirty-second of an inch, what is the relative capacity between the space of the ground joint and what you call the stricture?

Ans. The capacity of the stricture would be something more than twice the capacity of the opening at the ground joint. I cannot tell, accurately, without measuring the relative diameters of the parts, and calculating the capacities.

Cross-int. 9. In that answer, did you make any allowance for difference of diameters?

Ans. I did; that is what I referred to by the words "something more than."

Cross-int. 10. How high do you understand valves like Exhibit 2 to be raised, when in operation, with the steam at one hundred pounds pressure?

Ans. If used on a locomotive engine with the ordinary capacity for generating steam, when at work I think the valve would raise about a sixteenth of an inch. I have taken no means to ascertain the fact.

Cross-int. 11. When the valve is raised a sixteenth of an inch, what is the width of the opening between the outside of the valve and the inside of the lip or the place of escape? I mean that part which you have spoken of as the stricture.

Ans. I think the width would be a sixteenth of an inch, perhaps a little more. I cannot get at those parts of the exhibit so as to state more accurately.

Cross-int. 12. Why have you termed the annular space in valves like Exhibit 2, through which the steam escapes into the air, a stricture?

45 Ans. Because, to my mind, that term accurately describes the construction and operation of that device. It is a stricture, because it arrests or obstructs the free escape of the steam from the annular space between it and the ground joint. The resistance produced by it to the free escape of the steam produces a pressure of steam within it sufficient to overcome that resistance; and that is the pressure which, added to the direct pressure of the steam upon the area within the ground joint, which, together, counteract the increasing resistance of the spring which holds the valve to the seat. This pressure, which is ex

erted upon the annular space between the stricture and the ground joint, is proportioned to the resistance offered by the stricture to the free escape of the steam, and is the measure of the additional force exerted against the spring, in opening the valve, which it is the purpose of this arrangement to produce.

Cross-int. 13. Please explain what you mean by the words "the free escape of the steam."

Ans. I can, perhaps, explain it by supposing that the lip were entirely removed, in which case the valve would operate like the common safety-valve, and the steam escape freely into the air, and exerting no influence whatever upon the valve, after it had left the ground joint. Now, by adding the lip to the valve, and carrying out the seat nearly to meet it, leaving a narrow space between them which I have called the stricture, the free escape of the steam is prevented, and requires a pressure of steam within it sufficient to force the expanded steam through that narrow orifice; and that pressure is exerted upon the annular space of the valve within the stricture and outside of the ground joint, and that pressure is produced by obstructing the free escape of the steam by the stricture, as I have before stated.

Cross-int. 14. How narrow must that space be to operate as a stricture?

Ans. I cannot tell what the limits of the dimensions would be; that would depend on several things; that is, the pressure of the steam, the area of the annular space, outside the ground joint and within the stricture, as well as the width of the stricture itself.

46 Cross-int. 15. Suppose the valve to be Exhibit 2, the one to which these interrogatories relate, and suppose the pressure to be one hundred pounds, and the valve raised one-sixteenth of an inch, how narrow must the space referred to be to operate as a "stricture" in that case?

Ans. I think it should be just about what is shown in the exhibit, in order to act efficiently for the purpose for which it is designed, and that I suppose to be about three-hundredths of an inch, more or less, and that is as near as I can tell without trying experiments.

Cross-int. 16. Suppose that space to be three-sixteenths of an inch when the valve is raised one-sixteenth of an inch, under the other conditions stated in the preceding interrogatory, would it then operate as a stricture?

Ans. I don't think it would be to much purpose, the other conditions being as supposed.

Cross-int. 17. Suppose that space to be three thirty-seconds of an inch, and the valve to be raised one thirty-second, and the pressure to be one hundred pounds, would it operate in that case as a stricture?

Ans. I do not think it would act efficiently as a stricture, for the purpose for which the stricture is employed in the exhibit, although it might to some extent obstruct the free escape of the steam, and produce some pressure within it, but not enough to do the work required of it in the exhibit.

Cross-int. 18. If the space in valves like Exhibit 2, through which the steam escapes into the air, is three times as large as the opening at the ground joint, is the free escape of the steam obstructed, the pressure being, as before supposed, one hundred pounds?

Ans. It is, to some extent; but not enough to do much additional work in aiding to compress the spring which holds the valve to the seat.

THURSDAY, *April* 27, 1871.

Cross-int. 19. What is the theoretical velocity of steam under pressure of one hundred pounds from the valve like Exhibit 2?

Ans. I do not recollect the velocity at which steam escapes into
47 the atmosphere at any given pressure. These velocities are to be found in the books treating upon that subject, which are my only source of information. But the velocity of steam escaping from the stricture would be variable, according to the height to which the valve is raised and the amount of steam discharged during any unit of time. The velocity of the steam, also, at the ground joint would be variable under these conditions.

Cross-int. 20. What, in your judgment, was the velocity of the steam in the case of the experiment with Exhibit H[1], about which you have testified in the direct examination?

Ans. I cannot tell.

Cross-int. 21. State it approximately?

Ans. I cannot; I have no means of ascertaining it. I can only say that it must be somewhat less than the velocity of steam of one hundred pounds pressure escaping through an orifice into the open air.

Cross-int. 22. What would the velocity be in that case, as near as you can state, according to your best judgment?

Ans. I cannot state; it is not a matter about which an opinion can be formed without experiment or known data from which to judge; which data, as given in the books, I do not recollect.

Cross-int. 23. In your opinion, is the velocity of escaping steam, in that case over or under fifteen hundred feet a second?

Ans. So far as I have any recollection of seeing the velocity laid down in the books, I have a vague impression that the sum named in the interrogatory is in the neighborhood of the velocity given in the books under those conditions.

Cross-int. 24. Do I understand you correctly, if I understand you to say, in answering direct interrogatory 3 and other interrogatories, that the steam in escaping from valves like Exhibit 2 produces the effect of its action in raising the valve by expansion in the annular chamber surrounding the valve seat?

Ans. It does; after the steam has escaped from the ground joint, and before it escapes from the stricture.

Cross-int. 25. Do you mean to be understood as saying that the effect of the steam in that case is not due to the force or energy of its velocity?

48 Ans. Not exactly so; I mean to be understood as saying that the effect is produced by the expansive force of the steam within the annular space; and that, although accompanied by a high velocity of steam flowing into and out of that space, the agent which does the work is the expansive force of the steam tending to dilate and occupy greater space, which it is enabled to do by being restrained or prevented from escaping freely into the surrounding air.

Cross-int. 26. If the space through which it escapes freely into the surrounding air is larger in a valve like Exhibit 2 than the opening or space at the ground joint, is there any obstruction to the escape of the steam in point of fact?

Ans. There certainly is, for two reasons; first, because steam, being indefinitely expansible, instantly fills the space into which it flows with a lower pressure, corresponding to the amount of its dilation; and, second, that the current of steam as it issues from the ground joint is broken up in that space, and has to again reform the current to flow out of

the stricture, offering a resistance to the escape of the steam which is measured by the amount of pressure that would be required to force that volume of steam in its expanded condition through that orifice.

Cross-int. 27. Is it true, in your judgment, that the steam passing through valves like Exhibit 2 strikes against the curved lip and is thrown downwards on to the seat or bottom of what is called the annular chamber, thereby producing the effect of resisting the downward pressure of the spring?

Ans. I think not as stated in the interrogatory. The direction in which the steam flows into the annular space from the ground joint, that is, whether the current is directed towards the curved lip or towards the seat of the valve which forms the bottom of that enclosed space, is practically immaterial. The essential characteristics necessary to produce the result are that that enclosed space shall have its discharging orifice so restricted that it requires a generation of pressure in the steam to discharge from it.

Cross-int. 28. In point of fact is it true, in your opinion, that the steam passing through valves like Exhibit 2, as you suppose it to be constructed, acts in the way stated in the preceding interrogatory; that
49 is, that it strikes against the curved lip and is thrown downward on to the seat of the annular chamber?

Ans. It is true so far as this, that the current of steam issuing from the ground joint strikes first against the interior of the curved lip, and from that flows to all parts of the enclosed space; but it is not that the deflection of the steam downward upon the seat produces the action which assists to overcome the tension of the spring. It is the static pressure of the steam that does the work required.

Cross-int. 29. Is it true that the steam is thrown downward?

Ans. It is; downwards and upwards, too.

Cross int. 30. That is, the steam, by striking against the curved lip, is thrown downward on to the seat or bottom of the annular chamber.

Ans Some of it is thrown downward on to the bottom of the annular space within the stricture; some of it upward and some of it downward through the stricture without coming in contact with the seat.

Cross-int. 31. Do you mean by that answer anything more than this, that the steam, by its expansion, is thrown "upward and downward" in the annular chamber?

Ans. Yes; I mean by its expansion, and also by its deflection by the surface of the lip against which the issuing current impinges, it fills the enclosed space with steam.

Cross int. 32. Do you mean to make a distinction, by using the words "annular space" in your answers, between the annular chamber referred to in the question and something which you mean or intend to refer to by the term annular space?

Ans. By the term annular space, I mean that space within the stricture and outside of the ground joint. Somewhere in the examination of the matters connected with this suit I have seen the term "annular chamber" applied to the space outside of the stricture or within the exterior cup which is attached to the Richardson valve, as in Exhibit 2, and which serves the purpose of turning the steam upward after it has escaped from the stricture. For this reason I have used the term annular space as something entirely distinct from the space outside of the stricture, which I have seen called the annular chamber.

50 Cross-int. 33. Do you not mean by "annular space" that part of the valve which Richardson, in his specification, calls the annular chamber or "annular chamber D"?

Ans. I do.

Cross-int. 34. Is not some of the effect of resistance to the tension of the spring, in valves like Exhibit 2, due to the reaction produced by the steam being thrown downward in the annular chamber?

Ans. I do not think it is, materially. By reaction, in the question, I suppose to be meant the momentum of the steam in striking against the lip. As the weight of the steam is so small, notwithstanding its high velocity, the force exerted upon the lip by the direct impact of the steam upon it is small, and very far short of the force necessary to do the work intended to be done by that construction. This can be easily demonstrated to the senses by holding the finger in the escaping steam close to a safety-valve, which shows that the mere momentum of the steam is a very small quantity as compared with the elastic force which the steam can exert in a confined space.

Cross-int. 35. In your judgment, would it make any difference in the action of the steam in the annular chamber of Exhibit 2 if that chamber were made as large again, by dropping the bottom or seat and forming a wall or casing around it?

Ans. I do not understand what construction is meant in the interrogatory.

Cross-int. 36. Don't you understand what is meant by dropping the bottom or seat of the annular chamber?

Ans. I think I do.

Cross-int. 37. Suppose the bottom to be dropped, and a casing formed round the outer edge, extending up to the point corresponding with the outer edge of the seat of said chamber, and shown in Exhibit 2, would the action of the steam in such a chamber be different from its action in Exhibit 2?

Ans. If I understand the construction described in the interrogatory to be, in effect, merely forming a recess in the valve-seat, within the stricture and outside the ground joint, thereby enlarging the ca-
51 pacity of the annular space or chamber and retaining the stricture as before, under such circumstances I do not think the operation of the valve would thereby be materially changed.

Cross-int. 38. Suppose that annular space or chamber be formed to correspond with the space or chamber marked D, in Fig. 1, of the plaintiff's patent—I mean that part above what I think you have called the radial bars—assuming the bottom to be solid, would there be, then, any difference in the action of the steam in overcoming the tension of the spring?

Ans. I do not understand the construction mentioned. I do not see how that recess mentioned in the preceding answer could be made like the recess in the Ashcroft reissue, modified as described in the interrogatory. The construction of the valve and its relation to the recess are entirely left out of the interrogatory.

Cross-int. 39. How does a chamber, formed like that part of the drawing before mentioned, supposing that part below the letter D indicated by the notching to be solid, differ from a recess like that mentioned in your answer to cross-interrogatory 37?

Ans. Because, in my preceding answer, the recess was merely an enlargement of the annular space within the stricture, or within the lip of the valve. In the Ashcroft reissue, with the chamber modified as stated, the valve, with its lip, is entirely within the chamber, and considerable distance below its lip, and has no stricture at all, as described in the patent.

Cross-int. 40. Does it make any difference, in your judgment, whether

the lip of the valve be within the outside casing of the chamber or extending over it to the outside?

Ans. It does, a very material difference. The fact that the outside of the chamber approaches the valve to form a stricture upon the outside of the valve-lip, or projecting part, is not material so long as it forms a stricture to the enclosed chamber, and opens at the same time that the ground joint opens; but in the Ashcroft reissue the outside of the lip at the point at which it approaches the casing most nearly is considerable distance below the top of the casing, and the rising of the valve does not, in the least, increase that capacity, if it were made to act as a stricture by stopping up the bottom of the chamber D,
52 at the radial bars, as supposed in the interrogatory, in which case all the steam would have to escape upward past the valve. By such a modification the space below the lip of the valve becomes, in character, somewhat like the annular space in the Richardson valve, in which the steam would act by its pressure in lifting the valve and overcoming the increasing tension of the spring; but in this case the mode of operation of the valve and lip, and annular chamber below the valve, would be entirely changed.

Cross-int. 41. Do you mean by pressure a force different from the force due to the velocity of the steam?

Ans. I do. I mean the static pressure of the steam necessary to force it through the space between the valve and the casing.

Cross-int. 42. And you understand that to be the principle of Exhibit 2, do you not?

Ans. Generally speaking, yes, so far as it goes. It is not like Exhibit 2 in the property of opening the stricture in connection with opening the ground joint, so that the freedom of escape from the stricture shall correspond with the discharge of the valve at the ground joint.

Cross-int. 43. Please answer the preceding interrogatory and state whether you understand the principle of the action of Exhibit 2 to be the pressure of the steam, that is, static pressure, and not the principle of force derived from the velocity of the steam impinging upon, or striking against the inner face of the curved lip.

Ans. I have already answered the preceding interrogatory as well as I am able to answer it. As regards the present question, I am of opinion, as I have before stated, that in Exhibit 2 the force exerted within the lip, to aid in opening the valve, is the static force of the steam, almost entirely, and not the force of the impact of the current of steam against the under side of the lip.

Cross-int. 44. How high is the valve lifted—I mean a valve like Exhibit 2, when the annular space between the lip and the valve-seat ceases to act as a stricture?

Ans. I cannot tell; I never tried experiments with it which would enable me to answer.

Cross-int. 45. Is it not true, in the operation of that valve, that there is a portion of time when that opening or space does not operate as a stricture?

53 Ans. There probably is a very short period when the valve commences to open, and while open a very small distance; but the time is so short that the sound produced by the valve in opening is explosive in all those instances in which I have seen it operate.

Cross-int. 46. Does it operate as a stricture while the steam is freely escaping from the valve?

Ans. It does.

Cross-int. 47. Then, if I understand you correctly, that opening ob-

structs the passage of the steam into the air, by acting as a stricture, in the sense in which you use that word, although it may be something more than twice as large as the opening at the ground joint?

Ans. It does, most certainly.

Cross-int. 48. Is it not correct to say that a portion of the current of steam, through that opening, passes from the boiler—that is, freely, without obstruction, between the ground seat and the air?

Ans. I think not.

Cross int. 49. Why not?

Ans. Because the stricture opposes the free escape of the steam, and the steam being elastic, all parts of the current are affected by the resistance offered by the stricture, so that no part of the current of steam, flowing from the ground joint outward, is unaffected by that restraint.

Cross-int. 50. Suppose steam from a boiler, under the pressure assumed in the examination—that is, one hundred pounds—be allowed to escape from an orifice through a pipe, the other end of which, or the end through which the steam escapes into the air, is something more than twice as large as said orifice, would you consider that opening into the air to be a stricture, in the sense in which you have used the word stricture in this case?

Ans. I should not.

Cross-int. 51. Suppose the pipe to be somewhat larger at an intermediate point between the orifice and the opening into the air, would the outlet or said opening, in that case, be considered a stricture, as you understand it?

Ans. The outlet from the enlarged part would be, in relation to the enlarged part.

54 Cross-int. 52. Would that outlet be a stricture if twice as large as the orifice before mentioned?

Ans. It would if it were smaller than the enlarged part of the pipe.

Cross-int. 53. If there were two outlets from the enlarged part of the pipe, each twice the size of the "orifice," would they, or either of them, operate as a stricture?

Ans. That would depend on the proportions of the parts to each other. The induction-orifice has nothing to do with the fact whether the outlet is a stricture or not. If the discharging capacity of the outlets is less than the discharging capacity of the enlarged portion, it will, to that extent, be a stricture to the capacity of the enlarged part, more or less, according to the proportion which they bear to each other.

Cross-int. 54. In your judgment, will steam be discharged from the boiler through a pipe of the description before mentioned—that is, a pipe with the outlet twice as large as the end connected with the boiler, which we have called the orifice—less freely than a pipe having no such enlargement mentioned?

Ans. It will not.

Cross int. 55. How can the outlet in the case of the pipe having the enlargement be said to be a stricture, if it does not obstruct the free escape of the steam any more than the outlet of the pipe supposed to have no such enlargement?

Ans. It is a stricture in relation to the enlarged part, because it does not permit the steam to flow through it so freely as it does through the enlarged part, and therefore requires, in the enlarged part, an excess of pressure in the steam to give the requisite velocity of the steam through the contracted part, to enable the same quantity of steam to pass through

each. The inflowing current has nothing to do with this question of the stricture, as I have before stated.

Cross-int. 56. Which of the two pipes, constructed in the manner supposed in the preceding interrogatories—I mean the two having each one outlet—will discharge steam the more freely, in your opinion?

Ans. The two pipes referred to I suppose to be, one of them,
55 made with a constantly-increasing diameter from the inlet to the discharging end; and the other having the ends the same, but with an enlarged portion between the ends. The first-named one would probably discharge more freely than the other.

Cross-int. 57. I would call your attention to Exhibit G, which you have testified represents the Naylor valve, as you understand its construction. Please state whether a portion of the steam, which passes into the annular chamber surrounding the valve-seat, cannot be made to escape through the space around the lip of the valve, without altering the principle of the operation of that valve, as you understand the principle of its action.

Ans. It cannot, so far as I can see.

Cross-int. 58. Please explain your meaning by the words, "so far as I can see."

Ans. I simply meant to say that I could not see how the valve could operate as suggested in the interrogatory, without substantially changing the principle and character of its operation.

Cross-int. 59. Would not a portion of the steam escape from that annular chamber, by the opening around the lip of the valve, if the passage between the upper and the lower part of that chamber, at what you call the radial arms, were contracted?

Ans. It would if the passage were contracted sufficiently.

Cross-int. 60. Then, if you were requested to construct a valve of that description, so that a portion—say one-half—of the steam which passed into that chamber should escape by the opening around the lip, you would not construct it, so far as the interior of that chamber is concerned, like that valve, Exhibit G, before you, would you?

Ans. I should not, so far as the size of the openings between the radial bars is concerned.

Cross-int. 61. The passage of the steam, in that case, would be so far obstructed as to cause a portion of it to be thrown back or upwards towards the opening round the lip, would it not?

Ans. It would, if the openings were made small enough.

Cross-int. 62. You would make them small enough, wouldn't you, if you intended that a portion of the steam should escape through the space around the lip?

56 Ans. I should either do that or obstruct the escape-pipe in some other way.

Cross-int. 63. And the force of the steam escaping through the space around the valve would be dependent, in some measure, upon the size of the opening that you would make below, would it not?

Ans. It would.

Cross-int. 64. Would not the steam which passed into that chamber from the ground joint expand in that chamber? I mean the chamber when in the condition stated in the preceding interrogatories, with the opening below so contracted as to cause the desired portion of the steam to escape by the opening around the lip.

Ans. It would.

Cross-int. 65. Is Exhibit G, the Naylor valve, so called by you, so

constructed that the projecting lip of the valve and an annular recess are available in causing increased pressure on the valve?

Ans. There is some increased pressure upon the valve, but the annular chamber has no part in producing it. But the pressure so produced is not, in my judgment, for any useful purpose.

FRIDAY, *April* 28, 1871.

Cross-int. 66. Is there anything in the drawings of the plaintiff's patent to indicate the size of the opening or communication between the part of the annular chamber above what you have termed the radial bars and that part below them?

Ans. Not fully. There is that which shows clearly enough the width of the openings in a radial direction; but the number of bars, if they are more than two, could not be ascertained from the drawings; it needs a drawing in plan of these parts to show the other dimensions of the openings properly.

Cross-int. 67. Which portion of the annular space or spaces surrounding the exit, or central passage A, do you understand, from the specification of the plaintiff's patent, is meant or intended by the term, "annular recess," in the fifth paragraph of the specification?

Ans. I am not certain that I understand it at all. On first reading the paragraph, I thought it meant the same thing as the annular chamber D, mentioned in the first part of the paragraph; and I
57 should rather infer from the connection of the language that they both meant the same thing, as the first part of the paragraph states the parts in which the invention consists and the last part of the paragraph states what those parts are intended to do. But it has further occurred to me on reading it at this time whether the annular recess might not be applied to that portion of the valve within the lip; but the language is vague either way.

Cross-int. 68. In giving your testimony upon the subject of the substantial differences between the valve described in the plaintiff's patent and Exhibit 2, which meaning did you adopt, the latter or the former?

Ans. In my examination of the patent, and during my testimony, I have regarded the terms as meaning the same thing; and upon a further examination of the specification, since making the previous answer, I find that this was correct, because in the claims I find the term, annular recess, is used in three places, and is the part marked D.

Cross-int. 69. So far as the drawing and the position of the letters D indicates that recess, does it not reasonably appear to be above that part which you have called the radial bars?

Ans. So far as the mere position of the letters is concerned, they would indicate nothing but that the space in which they were placed was to be referred to in the description, and that the whole space in which they are placed was intended to be designated by those letters, unless something else showed to the contrary. Now, the space is shown in the drawing by dotted lines to extend below the radial bars, and there is no other letter to designate that part of the annular passage or chamber than the letters D.

Cross-int. 70. Then, did you understand the specification to refer to the space above the radial bars, so called, as the annular recess, as you read it, or to include some other portion of space in the drawings?

Ans. I understood the specification to refer to the whole of the annular space around the central passage and valve and within the valve-casing, or, in other words, that part of it below the valve.

Cross-int. 71. Did you understand any distinction to be in-

58 tended between the words "surrounding the valve-seat" and the words "surrounding the central passage A," in the fifth and ninth paragraphs of the specification, in your reading of the patent, before or when you answered direct interrogatories 3, 4, and 5?

Ans. When I was making the answers mentioned in the interrogatories, I did not have the comparison of the two terms mentioned, so far as I can now recollect, in my mind at all, or when previously examining the specification.

Cross-int. 72. Did you have the comparison of the two terms in your mind when you answered direct interrogatory 8?

Ans. I think not. I do not remember to have heard the comparison suggested until this morning by some of the previous questions.

Cross-int. 73. As Exhibit G is constructed, is there an annular chamber surrounding the whole of the main steam-passage?

Ans. There is, of all that part of the main steam-passage which is above the bottom of the exit-pipe. In the question it is called an annular chamber, but would be more appropriately called an annular passage, as it is the passage which leads the steam from the valve to the exit-pipe; but whichever term is applied to it, its operation is simply that of a passage, through which the steam flows after escaping from the valve.

Cross-int. 74. Please define annular chamber as you understand it.

Ans. The term, as used in the Ashcroft reissue, is, as I suppose, intended to describe such a chamber as is shown and described in the drawings and specification of the reissued patent, but used without reference to that patent. I should infer it to mean a chamber whose cross-section was an annulus.

Cross-int. 75. Would a cross-section of Exhibit G, at the centre of the angular or branch pipe, represent or show an annulus?

Ans. Not a complete one; it would be defective. A portion equal to the diameter of the branch pipe would be wanting. The remaining portion would be a portion of an annulus.

Cross-int. 76. At that part of the main passage, there is not an annulus surrounding it, but extending only partly round it.

59 Ans. At that part, the form of the passage in horizontal section is only a segment of an annulus; that is, the part which may not be considered a portion of the branch pipe.

(Counsel for plaintiff here puts in evidence a certified copy of specification and drawing of the letters patent of the United States, granted to W. Naylor, October 16, 1866, No. 58962, and marked "Exhibit K, C. W. T., Examiner.")

Direct examination resumed:

Int. 29. You have been asked some questions regarding the Naylor valve, marked "Exhibit G," with the annular passage stopped up at the radial bars; please state fully your opinion of the operation of that valve, with said annular passage thus stopped; and also state whether your opinions are verified by any and what experiments.

(Objected to.)

Ans. Some experiments were tried with Exhibit G at the time of trying the other experiments that I described in my direct examination; and one of them was with the annular space closed above the top of the radial bars, so that all the steam from the safety-valve escaped upward, through the opening between the lip of the valve and the casing. The result of the experiment was this: the valve commenced to open at between ninety and ninety-five pounds, and the steam gradually rose to a

hundred and two pounds, when the valve started upward suddenly with an explosive sound, with the steam escaping violently through the space between the lip of the valve and the casing, where it remained till the pressure of the steam in the boiler was reduced to eighty pounds, when the valve shut. The experiment was repeated, with this result: the valve commenced to open at ninety-two pounds, and the steam rose to ninety-eight pounds, when, with an explosive sound, the valve started up, where it remained till the pressure of the steam was reduced to eighty pounds, when the valve shut. The operation of the valve appeared to be this: that after the valve had commenced to open, and until the pressure of the steam rose to a hundred and two pounds, the
60 valve acted like the ordinary safety-valve, gradually opening the valve as the pressure of the steam rose. When the valve had risen to that height, the discharge of steam was so great that the opening between the lip of the valve and the casing offered so much resistance to the escape of the steam that it acted as a stricture, producing so much pressure on the under side of the lip as to send the valve upward violently, opening it a distance of about three-eighths of an inch. If the generation of the steam was sufficiently gradual, the blowing off of the steam would reduce the pressure in the boiler and gradually lower the valve, until the ground joint of the valve would retard the steam so much as to reduce the pressure under the lip, when the valve would drop to its seat. But if the generation of the steam was so rapid that it could not find escape between the lip and the casing, the pressure would not be lowered by the valve, and the valve would remain open until the pressure of the steam was lowered, by diminishing the rapidity of its production.

Int. 30. Did the valve rise as high as the top of the casing?

Ans. It did not.

Int. 31. Suppose the annular passage in Exhibit G was so contracted at the radial bars as to cause a portion of the steam to escape up past the lip of the valve, between the lip of the valve and the casing, what, in your opinion, would be the operation of the valve?

Ans. That would depend upon how large a proportion of the steam was sent upward, and what relation the united discharges, in both directions, bore to the volume of discharge from the ground joint. If both together were so small as to act as a stricture, and obstruct the escape of the steam into the air, so as to produce a pressure within the lip of the valve, it would then add that pressure to the pressure of the steam within the ground joint, to aid in opening the valve. If, on the other hand, the discharge of the steam from the ground joint was so small that those openings offered a free escape to it, although part of the steam escaped above and part below, their operations to produce pressure on the under side of the lip of the valve would be immaterial, and the valve would operate, so far, as an ordinary safety-valve.

61 Int. 32. In the first alternative, stated in your last answer, how would the operation of the valve differ from the operation of said valve with the annular passage entirely closed, as supposed in the 29th interrogatory?

Ans. It would differ in degree only, I think; that is, with all the steam escaping upwards a lesser volume of escaping steam would produce a greater upward pressure on the lip of the valve than if a portion of the steam escaped in the other direction, because less pressure would be required under the lip to discharge the steam from the two orifices of escape than if it were all compelled to escape through the upper one.

Int. 33. What, in your opinion, is the usual rise of the Richardson valve, in practice?

Ans. When the engine has a full or working fire on, and the engine is stopped, I should judge about a sixteenth of an inch, perhaps a little more; this is a matter of opinion, merely. I have never tried any experiments to test it.

Int. 34. Please explain the working of the common safety-valve in relation to the discharge of steam when held down by a spring.

Ans. The discharge commences when the pressure of the steam upon the acting surface of the valve is sufficient to overcome the tension of the spring; and if the valve is raised to give a greater opening the spring is compressed and the tension of the spring is increased, producing a greater pressure on the valve than when it is upon its seat, so that the greater the discharge required from the valve the greater will be the pressure of the steam, so that in case there is a rapid generation of the steam, and a great volume to be discharged, the pressure will rise considerably higher than that required to open the valve at first. For this reason, if the safety-valve is set to blow off at a point of safety, and if the boiler generates steam rapidly, the pressure must rise considerably above that point in order to be discharged by the valve.

Int. 35. Look at Exhibit L, and state what that is, and what alteration in a whole valve, constructed like it, would make a common safety-valve?

Ans. Exhibit L is a section of the Richardson, and its seat;
62 and to make it in effect a common safety-valve, it is only necessary to remove the lip, so that it shall offer no obstruction to the escape of the steam, or to turn away the outside of the valve-seat, so as to leave a free passage of the steam into the air.

Cross-examination resumed:

Cross-int. 77. Is not the superiority of valves like Exhibit L, over the common valve, due to the fact or principle that the steam, after leaving the ground joint, is caused to exert a further power or force upon the valve?

Ans. It is.

Cross-int. 78. Is it not necessary to take into consideration, in the construction of safety-valves, the effect of the escaping steam in the closing of the valve?

Ans. In the common safety-valve it is not; in the Richardson valve it is.

Cross-int. 79. It is not a fact that the common safety-valve does not close at the pressure at which it opens, but at some pounds below it?

Ans. I think not, if the valve works freely.

Cross-int. 80. How extensively have you observed the action of the common safety-valves in this respect?

Ans. I cannot state in language. My experience in building steam-engines has extended over many years; it has been the leading business of my life. I have designed a great many safety-valves of the common kind, and have seen a great many of them operate.

Cross-int. 81. How near, in practice, to the opening pressure do they close?

Ans. If the parts work free, within less than half a pound; probably, in a large valve, not so much as that.

Cross-int. 82. When valves like Exhibit 2 or L are raised one-sixteenth of an inch, what is the area of the opening?

Ans. I can't tell without calculating it.

W'M C. HIBBARD.

63 *Deposition of Cephas Manning.*

SATURDAY, *April* 29, 1871.

Direct examination by Benjamin Dean, esq., of counsel for respondent:

Int. 1. State your name, age, residence, and occupation.

Ans. My name is Cephas Manning; age, forty-seven years; reside in Boston; I am a machinist.

Int. 2. Have you been connected with the business of railroad management; and, if yes, in what capacity, on what railroads, where located, and for what time?

Ans. I have been railroading, as master-mechanic, for about twenty years. During this time, about two years ago, I was superintendent for about one year of the Grant Locomotive Works, in Patterson, New Jersey. I was master-mechanic on the Milwaukee and Prairie du Chien Railroad for about nine years. I was about three years in the same capacity on the Marietta and Cincinnati Railroad. The rest of the time on the Louisville, Alton and Chicago Railroad, and the New York Central.

Int. 3. Do you remember when your attention was first called to the Richardson valve, like valves marked "Exhibits 2 and L"? If yes, by whom, and when, and where?

Ans. In December, 1866, at West Albany, New York, M'r Richardson, the patentee, came to the works—the New York Central Works, at West Albany—and applied the first one, the first one I ever saw.

Int. 4. Has the use of said valves increased since said time; and, if yes, to what extent?

Ans. It has increased very rapidly. After giving M'r Richardson commission to put on one, I thought well of it, and in two or three days had him put on three, to see what objections could be found. After about three months I recommended the company to adopt their use, which they did. I know of its immediately going into use on the New York and Erie, Pennsylvania Central, and several others.

64 Int. 5. Did you place any of said valves on locomotives while you were superintendent of the Grant Locomotive Works, and to what extent?

Ans. The most of the engines which were built at the time, which was about three a week, went out with the Richardson valve on.

Int. 6. Had you ever before seen any valve of similar construction or mode of operation?

Ans. I never had; that is to say, I had never seen anything on valves, outside of the valve-seat, except a collar to turn up the steam, which was placed on the dome-cover, leaving a space about three-eighths of an inch between the valve and collar.

Int. 7. Was the valve you have described in your last answer the common safety-valve?

Ans. It was.

Int. 8. Please state the operation of said common safety-valve in practice, and the operation in practice of the Richardson valve.

Ans. The common safety-valve, after it begins to rise, holds on to steam enough to increase the pressure on the boiler. Well, I have known cases, after shutting off immediately, on the road, I have known a correct steam-gauge to go up twenty-five pounds, with levers and springs in order. The Richardson valve relieves the pressure in the boiler immediately after raising, and I have never seen an increase of pressure after the valve is raised.

Int. 9. Under what circumstances in practice is there usually the

greatest increase of pressure in locomotive-boilers, calling for the use of safety-valves?

Ans. Immediately after shutting off, when running, and when working the engine very hard; for instance, getting flagged up on the road when they are not prepared for it.

Int. 10. What do you mean by the words getting "flagged up"?

Ans. I mean when the red flag is exhibited for stopping the train, in the case of danger or otherwise. When working the engine hard we are generating the most steam; shutting off suddenly the pressure increases fast, calling for relief by safety-valves.

65 Cross-examination by J. B. Robb, esq., of counsel for complainant:

Cross-int. 1. Did you ever see any valves like Exhibit H[1], so far as you can judge from its outward appearance?

Ans. To all appearance the valve itself is the Richardson valve, saying nothing of the seat, without taking it apart.

Cross-int. 2. Cannot you tell without taking it apart whether there is an annular recess outside of, around, and below the edge of the lip?

Ans. No, sir.

Cross-int. 3. Is there, to your eye, as you see the valve before you, an annular recess outside, around, and below the lip of Exhibit 2?

Ans. Is this annular recess you speak of in the valve or in the seat?

Cross-int. 4. Did the Richardson valves you have testified about have the appearance outside of the lip of the valve of Exhibit 2, or the appearance of Exhibit H[1]?

Ans. I should say Exhibit 2. No, sir; I take that back; there is some slight difference. Well, I have made that fuss for nothing. I can see no difference between the valve I have testified about and Exhibit 2.

Cross int. 5. You have never seen the Richardson valve, as you call it, used in the shape of Exhibit H[1]; I mean having no projection from the valve below the lip on the outside of the valve, corresponding with the projection formed on Exhibit 2, below and outside of the lip, have you?

Ans. Well, I could not say; I may have, but don't remember.

Cross-int. 6. Don't you think you would be apt to remember it if you had?

Ans. It is a matter of uncertainty with me, just as I can remember now.

Cross-int. 7. Hear your answer to direct interrogatory 3 read again and state whether you wish to qualify it.

Ans. I don't know as I can do any better.

66 Direct examination resumed:

Int. 11. Please take apart Exhibit H[1] and state what the valve is like, as far as it goes.

Ans. I find this to be the Richardson valve, as first applied, with the exception of this additional lip on the seat. I would not say positively whether the first one had the lower lip or not.

Cross examination resumed:

Cross-int. 8. Have you examined the Richardson patent, and have you such a distinct recollection of the construction of the valve as described therein as to enable you to testify positively that Exhibit H[1] is constructed in conformity with the specification of that patent?

Ans. I don't remember ever having seen the specification.

CEPHAS MANNING.

Deposition of Henry L. Leach.

Direct examination by Benjamin Dean, esq., of counsel for respondent:

Int. 1. State your name, age, residence, and occupation.

Ans. My name is Henry L. Leach; age, fifty years; reside in Boston. I am superintendent of the Hinkley & Williams Works, in Boston—locomotive-builders.

Int. 2. How long have you been connected with the business of building locomotives?

Ans. Most of the time for twenty-seven years.

Int. 3. Have you at any time had the agency in Boston for the sale of the Richardson steam safety-valve; and, if yes, how long?

Ans. Yes, I have, for three years and three months.

Int. 4. What other valve have you known to be used on locomotives?

67 Ans. What we call the old-fashioned safety-valve, with cone seat, and also with a flat seat. These are the only kinds that were in general use.

Int. 5. Before the introduction of the Richardson valve by M'r George W. Richardson, had you known of, or seen, any valve like it?

Ans. I had not.

Int. 6. Did you ever have any conversation with Edward H. Ashcroft, plaintiff in this case, upon the subject of said valve? If yes, give said conversation.

Ans. Yes, I have. I was trying to think where the conversation with Charley left off and the conversation with Edward H. began. Ashcroft said he was making the Naylor valve. I said, you have some castings like the Richardson valve. He said they were not Richardson's, but Naylor's. He asked me to come into his office, and showed me a valve which I said was Richardson's. He said it was Naylor's. I said, if it was Naylor's valve it was Richardson's manufacture. He then said, if it was Richardson's manufacture it was Naylor's valve. He then said he had bought Naylor's right to a safety-valve on which Richardson was an infringer. He took out some patent papers from his drawer, and read an extract from it, where Naylor claimed the annular groove. He then went on to state the reason he came to take hold of the valve. He said that on a former valve that he made he wrote to Richardson, asking him to have the two valves put together, or united, and go into company in the manufacture; that Richardson, in return, wrote him a saucy letter, saying his valve was an infringement, and that if he manufactured and sold he would prosecute him. He said it made him mad, and that he felt determined to find something, if he could, that would be equally as good as Richardson's; that he sent to his agent at Washington, asking him to look over the models at the Patent Office, and see if he could find anything like it. The agent returned an answer that he could not find anything; that he wrote him a second time to look them over, saying that in the large number of models in the Patent Office there must be something similar to the Richardson valve. His

68 agent wrote that he could not find anything similar to the Richardson. Ashcroft said he went on himself to Washington, went into the Patent Office, and found a valve with an overhanging lip. He said he took the model to the Commissioner or examiner, and found it was patented by Naylor in England; that he went over to England and bought Naylor's right; came back to this country and got it repatented and antedated; and that the date was prior to Richardson's patent. That is the substance of the conversation.

(Answer objected to, as having no legitimate bearing upon any issue in this cause.)

Int. 7. When did that conversation take place?

Ans. I think it is little more than a year ago.

Int. 8. By whom was the valve, of which you have spoken in your last answer, made? I mean the valve which you have spoken of as Richardson's manufacture.

Ans. By Richardson.

Int. 9. How general has become the use of the Richardson valve since its introduction by M'r Richardson?

Ans. I can only give an opinion. So far as my observation goes, I should say one-half the locomotives in the country had them on.

Int. 10. How is it with the locomotives built at the Hinkley & Williams Works?

Ans. We put them on to all engines we build, except when ordered otherwise.

Int. 11. How generally were they in use at the time of your conversation with M'r Ashcroft?

Ans. I don't know. At that time railroads were generally adopting them.

(No cross-examination.)

H. L. LEACH.

69 RESPONDENT'S EXHIBITS.

Exhibit A.—C. W. Tuttle, Examiner.

SAFETY-VALVES.

Letters patent No. 1038, dated 25th April, A. D. 1863, to Charles Beyer, of the firm Beyer, Peacock & Co., Gorton Foundry, Manchester, in the county of Lancaster, engineers, for the invention of "Improvements in safety-valves."—A communication from abroad by Johann Andreas Schubert, professor of engineering at the Polytechnic School at Dresden.—Sealed the 16th October, 1863, and dated the 25th April, 1863.

Provisional specification left by the said Charles Beyer at the office of the Commissioners of Patents, with his petition, on the 25th April, 1863.

I, Charles Beyer, of the firm Beyer, Peacock & Co., Gorton Foundry, Manchester, in the county of Lancaster, engineers, do hereby declare the nature of the said invention for "Improvements in safety-valves," communicated to me from abroad by Johann Andreas Schubert, professor of engineering at the Polytechnic School at Dresden, to be as follows:

It is well known that the common or ordinary safety-valve, when loaded to counterbalance a given pressure of steam, does not lift or blow off freely until the pressure has increased to a considerable extent above the pressure fixed upon, consequently the boiler is but slowly relieved of the excess of pressure, owing to the small area of the opening of the valve.

70 The object of this invention is wholly or partially to remove this defect, by causing the safety-valve, when the pressure has become sufficient to overcome the weight upon it, to lift much higher than the ordinary safety-valve, and thus give a larger opening for the escape of the steam or other fluid.

This invention consists in forming a flange around the valve, com-

mencing at the outer edge of the valve facing, which flange is undercut, and concave in shape, and the concave side is towards the seating of the valve, which has also a flange upon it, commencing at the outer edge of the valve-seating, but the upper surface of this flange is convex, and corresponds nearly to the concave surface of the flange upon the valve. There is a slight space between the concave and convex surfaces of the two flanges, which diminishes towards the outer edges of the flanges. When the steam begins to escape from between the surfaces of the valve, it gets between the concave and convex surfaces of the two flanges, and its force thus acts upon a larger area, and reacts upon the concave surface of the valve, and causes it to open to a greater extent than the ordinary valve.

Specification in pursuance of the conditions of the letters patent filed by the said Charles Beyer in the Great Seal Patent Office on the 21st October, 1863.

To all to whom these presents shall come: I, Charles Beyer, of the firm of Beyer, Peacock & Co., Gorton Foundry, Manchester, in the county of Lancaster, engineers, send greeting:

Whereas Her most excellent Majesty Queen Victoria, by her letters patent, bearing date the twenty-fifth day of April, in the year of our Lord one thousand eight hundred and sixty-three, in the twenty-sixth year of her reign, did, for herself, her heirs and successors, give and grant unto me, the said Charles Beyer, her special license that I, the said Charles Beyer, my executors, administrators, and assigns, or
71 such others as I, the said Charles Beyer, my executors, administrators and assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should, and lawfully might, make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an invention for "Improvements in safety-valves," a communication from Johann Andreas Schubert, professor of engineering at the Polytechnic School at Dresden, upon the condition (amongst others) that I, the said Charles Beyer, by an instrument in writing, under my hand and seal, should particularly describe and ascertain the nature of the said invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said letters patent.

Now know ye, that I, the said Charles Beyer, do hereby declare the nature of my said invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement and accompanying drawings (that is to say):

It is well known that the common or ordinary safety-valve, when loaded to counterbalance a given pressure of steam, does not lift or blow off freely until the pressure has increased to a considerable extent above the pressure fixed upon, consequently the boiler is but slowly relieved of the excess of pressure, owing to the small area of the opening of the valve.

The object of this invention is wholly or partially to remove this defect, by causing the safety-valve, when the pressure has become sufficient to overcome the weight upon it, to lift much higher than the ordinary safety-valve, and thus give a larger opening for the escape of the steam or other fluid.

This invention consists in forming a flange round the valve, commencing at the outer edge of the valve facing, which flange is undercut, and

concave in shape, and the concave side is towards the seating of the valve, which has also a flange upon it, commencing at the outer edge of the valve seating, but the upper surface of the flange is convex,
72 and corresponds nearly to the concave surface of the flange upon the valve. There is a slight space between the concave and convex surfaces of the two flanges, which diminishes towards the outer edge of the flanges. When the steam begins to escape from between the surfaces of the valve, it gets between the concave and convex surfaces of the two flanges, and its force thus acts upon a larger area, and reacts upon the concave surface of the valve, and causes it to open to a greater extent than the ordinary safety-valve.

The accompanying sheet of drawings shows a sectional elevation of a valve formed according to the invention.

a is the flange from the seating, having the convex surface towards the valve, and *b* the flange upon the valve, having the concave surface towards the seating of the valve; *c*, valve spindle; *d*, valve lever; d^1, its fulcrum. This improved valve will, as before stated, lift promptly when the required pressure is attained, and will open to a much greater extent than the common safety-valve. Extra pressure upon the valve will readily close it after it has lifted, but it does not shut, self-acting, till the pressure in the boiler has diminished several pounds below the pressure at which the valve was lifted. To cause the safety-valve, when it has been lifted by the excess of pressure, to close again, self-acting, when the pressure has diminished to a given extent, the inventor employs the additional apparatus which is also shown upon the accompanying drawings in connection with his improved valve. It will be seen that the valve is enveloped by a pipe or hood (*e*) which serves to conduct away the steam escaping from the valve, the outlet for this steam being at e^1. This hood has a hole in it through which the top of the valve passes; it has also another hole at e^2, which communicates with passages in a conical plug *f*, in communication with a vertical pipe *g*, the conical plug forming a joint for the vertical pipe to swivel upon. The vertical pipe is screwed into the upper side of a cylindrical vessel g^1, and another pipe g^2, which is bent as shown, screws into the lower side of the vessel g^1, and the other end of this bent pipe screws into the lower side of another cylindrical vessel *h*, which has a double valve-box h^1, screwed into its upper side, as shown. The valve-box contains a spindle *k* with reversed cone facings, one for the upper, the other for the lower
73 valve-seating. The upper end of the valve-spindle *k* is screwed, and has an adjusting screw k^1 upon it, the shoulders of which rest upon a forked bracket k^2 secured to the hood (*e*) as shown. Each end of the cylindrical vessel *h* has a pivot formed upon it, and one end of a link *l* is jointed upon each pivot; the other ends of the links are jointed with a cross pin d^2 fixed on the end of the lever *d*. It will now be seen that the cylindrical vessels g^1 and *h* and their connected parts, are sustained partly upon the lever *d* and the swivel cone plug *f*, and when the safety-valve is shut, the screw k^1 is adjusted so that the cone on the spindle *k* for the lower valve will just be open, in which position the air can enter the vessel *h*. The vessel *h* is at a higher level than the vessel g^1, which is filled with mercury, which communicates by the pipe g^2 with the vessel *h* but only reaches to its lower side when the safety-valve is closed, and the steam is not escaping. When the safety-valve opens, the end of the lever *d* will lift, and with it the vessel *h* and its connected parts. The vertical pipe *g* and connected vessel g^1 will also turn slightly upon the swivel conical plug *f*. The valve-spindle *k* will then be sustained upon the lower valve-seating (or so much of its weight as remains

unbalanced by the buoyant power of the mercury), and as the pressure of the escaping steam will act upon the surface of the mercury in the vessel g^1, it will be forced into the vessel h, and by this means an increased load will be put upon the valve-lever d. Should the mercury rise into the valve-box h^1, its escape will be prevented by the rise of the valve-spindle k till it comes against the upper valve-seating, as the spindle is of such proportions, and so arranged as to descend into the mercury, so as to float when the mercury ascends sufficiently high in the vessel. If the pressure of the steam diminishes so as not to sustain the mercury in the vessel h, then when a part has run back, the valve-spindle k will descend, and will rest upon the lower seating, and prevent the admission of air, and consequently the escape of mercury from the vessel till the safety-valve closes, when the lever d, vessel h, and connected parts will descend, and the adjusting screw-nut k^1 of the valve-spindle k will rest on the forked bracket k^2, in which position the valve is opened, consequently the remainder of the mercury in the vessel
74 will be permitted to return to the vessel g^1. If preferred, the vessel g might be placed on the fulcrum of the lever d and the vessel h at the end of the lever d communicating by a pipe (g^2), the arrangement of the other parts being modified accordingly. In place of mercury, water or other fluid may be used, the capacity of the vessels g^1 and h being made sufficiently large.

I have now particularly described the nature of the invention communicated to me, and the mode of carrying the same into effect, and wish it to be understood that I claim,

Firstly. The construction of safety-valves with flanges substantially in the manner and for the purposes herein before described.

Secondly. Apparatus for self-closing safety-valves after they have been lifted by the pressure of the steam or fluid, as herein before described.

In witness whereof, I, the said Charles Beyer, have hereunto set my hand and seal, this sixteenth day of October, in the year of our Lord one thousand eight hundred and sixty-three.

CHARLES BEYER. [L. S.]

Exhibit B.—C. W. Tuttle, examiner.

The U. S. Patent Office to all persons to whom these presents shall come, greeting:

This is to certify that the annexed is a true copy from the bound volumes of English patents in the library of this office.

In testimony whereof, I, Samuel S. Fisher, Commissioner of Patents, have caused the seal of the Patent Office to be hereunto affixed this sixteenth day of February, in the year of our Lord one thousand eight hundred and seventy, and of the Independence of the United States the ninety-fourth.

[L. S.] SAMUEL S. FISHER,
Commissioner.

75 Specification in pursuance of the conditions of the letters-patent filed by the said Thomas Green in the Great Seal Patent Office on the 9th November, 1859.

To all to whom these presents shall come, I, Thomas Green, junior, of Old Broad street, in the city of London, send greeting:

Whereas Her most excellent Majesty Queen Victoria, by her letters

patent, bearing date the ninth day of May, in the year of our Lord one thousand eight hundred and fifty-nine, in the 22d year of her reign, did, for herself, her heirs, and successors, give and grant unto me, the said Thomas Green, my executors, administrators, and assigns, or such others as I, the said Thomas Green, my executors, administrators, and assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an invention for "Improvements in apparatus applicable to steam-boilers, to obtain greater security against explosion," upon the condition (amongst others) that I, the said Thomas Green, my executors or administrators, by an instrument of writing, under my, or their, or one of their hands and seals, should particularly describe and ascertain the nature of the said invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said letters patent:

Now know ye that I, the said Thomas Green, do hereby declare the nature of the said invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement thereof, (that is to say):

This invention has for its object improvements in apparatus applicable to steam-boilers, to obtain greater security against explosion. For these purposes the feed-water in its passage to a steam-boiler, acts on a piston in such a manner as to prevent the piston being pressed downwards, which, in itself, is not new, but in this arrangement
76 the other side of the piston is constantly pressed on by steam, there being a communication between the steam-boiler and the cylinder in which the piston works; at the same time the steam is prevented from sounding a whistle, in connection with the cylinder, so long as the supply of water is properly kept up; so soon, however, as the supply of water fails, the piston will be pressed down by the steam, and a valve of a steam-whistle (in connection with a piston) will be opened, and the whistle will be sounded by the passage of steam through it. In order that the piston may be allowed to descend or move as early as possible after the force-pump has ceased to supply water properly, there is a small outlet through which water is constantly allowed to escape, and such outlet is, by preference, through a cone, the upper end of which is small, so that no substance or matter can rest on the opening so as to stop it.

Another part of the invention consists in an arrangement of apparatus for conducting the steam from a boiler into the fireplace, when the water-level in the boiler falls below a certain point, and this is accomplished by means of a plug or valve which closes the passage of a pipe leading from the upper part of the boiler to the fireplace.

This plug or valve is arranged to be opened when a float in the boiler descends to a certain extent. For this purpose the plug is acted upon by a lever, and such lever is acted upon by a rod in connection with the float.

In constructing a safety-valve, having a spherical or curved undersurface (whether weighted below or above), I apply a disc above the valve, of larger diameter than the valve, and around the valve is a cup of a larger diameter than the disc, and the parts are so arranged that the disc, when the valve is closed, descends some distance into the cup,

below the upper edge thereof, leaving a small space between the edge of the periphery of the disc and the interior of the cup.

Having thus stated the nature of my invention, I will proceed more fully to describe the manner of performing the same.

Description of the drawings.

Figure 1 shows a section of apparatus constructed and combined according to my invention.

77 Figure 2 is a plan thereof, partly in section; figure 3 is a transverse section thereof. *a* is the inlet, connected with the force-pump for supplying water to a boiler, the water passing freely into the boiler so long as the passage is open thereto, by the float and valve used for that purpose, and the water passes through the outlet *b* to the boiler, or to an escape outlet, when the supply is not required to the boiler; *c* is a steam inlet communicating constantly with the boiler, so that there will be a constant pressure of steam on the piston *d*, tending to force it downwards, whilst the pressure of water, if properly and continuously supplied by the force-pump, will press on the under side of the piston *d*, and prevent its descending; but should any defect in the force-pump, or other cause, render the supply of water insufficient, then the pressure of the steam on the upper side of the piston *d* will prevail, and the piston will be caused thereby to descend and open the valve *e* to the whistle *f*. The apparatus is arranged in such manner that the piston *d* may descend a distance before it acts on the stem of the valve *e*, and this distance may be greater or less, according to the desire of the parties applying the apparatus. *g* is a conical nipple, through which there is a constant outgoing of small quantity of water. This cone is covered by a perforated shield, in order to prevent any matter getting to the conical outlet which would clog it; by this arrangement, should the force-pump cease to supply sufficient water, a quantity of the water would continue to escape through the nipple, and the piston would immediately descend. I would state that it is not new to cause the water fed to press on a piston so as to prevent a whistle being sounded. I do not, therefore, claim the same, and I would state that the peculiar character of this part of the invention consists in the combination of the parts *a*, *c*, *d*, and *g*.

In order to convey the steam of a steam-boiler into the ash-pit when the water falls below a certain point, and thus to damp the fire and relieve the pressure on the boiler by allowing the steam to blow off, I employ an apparatus such as is shown at figure 4, where *h* is a float in a steam-boiler in connection with a lever *i*, also within the boiler. The other end of this lever acts on a slide-valve *j*, or it may be arranged to act

78 on any other suitable slide or valve; *k* is an outlet which is connected with the ash-pit of the boiler-furnace, by which arrangement, when the water-level in the boiler sinks, the valve *j* will be opened and the steam will escape to the ash-pit.

I would state that this part of the invention consists in the combination of mechanical parts herein described. Figure 5 shows a safety-valve and apparatus constructed and combined according to another part of my invention; *l* is a valve having a spherical under-surface; *m* is a disc of larger diameter than the valve so that any steam escaping beyond the valve will tend to press the disc and valve upwards; *n* is a cup, the upper edges of which rise somewhat above the disc, and there is a small space below the inner surface of the cup and the outer edge of the disc; *o* is a weighted rod to the valve, and the disc is also shown

to be weighted. I would state that the peculiarity of this part of my invention consists in the combination of the parts *l*, *m*, and *n*, as herein described.

In witness whereof, I, the said Thomas Green, have hereunto set my hand and seal, this ninth day of November, in the year of our Lord one thousand eight hundred and fifty-nine.

THOMAS GREEN, JR. [L. S.]

Exhibit C.—C. W. Tuttle, examiner.

SAFETY-VALVES.

Letters patent No. 1830, dated July 21st, A. D. 1863, to William Naylor, of Queen's Road, Dalston, in the county of Middlesex, engineer, for the invention of "Improvements in safety-valves, and in apparatus connected therewith." Sealed the 19th January, 1864, and dated the 21st July, 1863.

Provisional specification left by the said William Naylor at the office of the commissioners of patents, with his petition, on the 21st July, 1863.

I, William Naylor, of Queen's Road, Dalston, in the county of
79 Middlesex, engineer, do hereby declare the nature of the said invention for "Improvements in safety-valves, and in apparatus connected therewith," to be as follows:

This invention relates to certain improvements in safety-valves, and consists in the employment of valves (when used with levers loaded by dead weights), having the edges of the valve outside the valve seating cupped or turned downwards, so that the main body of the steam as it escapes from the boiler being directed downwards, strikes against the bottom of a suitable recess, or into a chamber round the pipe leading from the boiler to the valve, and consequently the recoiling action of the steam acts upwards against the under surface of the valve as it issues forth into the atmosphere, and by such recoiling action of the steam the valve is assisted in opening, so as to counteract the resistance of the atmosphere to the issuing steam, which resistance is virtually equal to an extra load on the valve; or the edges of the valves may project horizontally beyond the valve seat, so that the steam, after leaving the valve facing, may act under the projection as it rushes into the atmosphere, virtually acting on a larger valve surface after leaving the boiler, and before its final exit into the atmosphere. When using a spring for resisting the valve from opening, I purpose using a lever of the first order, one end resting by a suitable pin upon the safety-valve, and the other end of the lever resting upon the spring. The end resting upon the spring I purpose bending downwards about 45 degrees, so that when the valve is raised by the steam, the other end of the lever is depressed upon the spring downwards, and at the same time is moved inwards towards the fulcrum, thus virtually shortening that end of the lever, and thereby counteracting the additional load upon the valve as it is raised from its seat by the greater amount of compression put upon the spring. In some cases I purpose placing the spring in tension, and acting at right angles to the valve lifting. In some cases I propose to employ a cylinder with a piston acting against the spring, resisted by the end of a lever projecting over from the valve; the compression of this spring will indicate the pressure of the steam in the boiler, and when the maximum pressure is attained it will assist in lifting the valve.

80 Specification in pursuance of the conditions of the letters patent filed by the said William Naylor in the Great Seal Patent Office, on the 21st of January, 1864.

To all to whom these presents shall come, I, William Naylor, of Queen's Road, Dalston, in the county of Middlesex, engineer, greeting:

Whereas her most excellent majesty Queen Victoria, by her letters patent, bearing date the twenty-first day of July, in the year of our Lord one thousand eight hundred and sixty-three, in the twenty-seventh year of her reign, did, for herself, her heirs and successors, give and grant unto me, the said William Naylor, her special license that I, the said William Naylor, my executors, administrators and assigns, or such others as I, the said William Naylor, my executors, administrators or assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an invention for "Improvements in safety-valves, and an apparatus connected therewith," upon the condition (amongst others) that I, the said William Naylor, my executors or administrators, by an instrument in writing, under my hand and seal, or under the hand and seal of one of them, should particularly describe and ascertain the nature of the said invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said letters-patent.

Now know ye, that I, the said William Naylor, do hereby declare the nature of my said invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement, reference being had to the accompanying drawings, and to the letters and figures marked thereon, that is to say:

My said invention relates to certain improvements in safety-valves, and consists, when using a spring for resisting the valve from
81 opening, in the employment of a lever of the first order, one end resting by a suitable pin upon the safety-valve, and the other end of the lever resting upon the spring, the end resting upon the spring being bent downwards to an angle of about 45° from the fulcrum, so that when the valve is raised by the steam the other end of the lever is depressed upon the spring downwards, and at the same time is moved inwards towards the fulcrum, thus virtually shortening that end of the lever, and thereby counteracting the additional load upon the valve as it is raised from its seat by the greater amount of compression put upon the spring. In some cases I purpose placing the spring in tension, and causing it to act at right angles to the valve. I also propose to employ a cylinder with a piston acting against a spring, resisted by the end of a lever projecting over from the valve, the compression of this spring will indicate the pressure of the steam in the boiler, and when the maximum pressure is attained it will assist in lifting the valve.

And in order that my said invention may be fully understood, I shall now proceed more particularly to describe the same, and for that purpose I shall refer to the several figures on the sheets of drawings hereunto annexed, the same letters of reference indicating corresponding parts throughout all the figures.

Figure 1 on sheet 1 of my drawings represents a vertical section of a safety-valve provided with my improved compensating valve lever; figure 2 is a sectional plan taken along the line 1, 2, in figure 1; figure

3 is a front elevation of the valve complete; and figure 4 is an elevation of the opposite side of the valve to that shown in figure 3.

A is the main thoroughfare leading direct from the boiler; B is a lateral branch or escape passage for a portion of the steam after it has passed the valve C. I prefer to make this valve project over the edges of the exit passage A, and to curve the projecting edges of the valve slightly downwards, as shown in the drawing (figure 1), so that the steam on issuing between the valve and its seat will impinge against the curved projecting portion of the valve, and a portion of it will be directed downwards into the annular chamber D, surrounding
82 the central passage A, which chamber D communicates at once with the branch exit pipe B, whilst the other portion of the steam ascends past the edges of the valve. By this means I am enabled to avail myself of the recoil action of the steam against the valve for the purpose of facilitating the further lifting of such valve when once opened, but I wish it to be understood that I lay no claim to such recoil action, nor to the extension of the valve laterally beyond its seat. E is my improved valve lever: it works on a fulcrum at F, and is made to hold down the valve at one end through the rod or spindle G, by the action of the helical spring H, which exerts an upward pressure against the opposite end *a* of the lever. This end *a* of the lever is bent downwards, as shown in my drawing, and is acted upon directly by the upper end of a rod or spindle I, situate inside the coils of the spring H and provided with a flange or collar *b*, against which the upper end of the spring bears, the lower end of the spring resting upon a cross-bar K through a hole, in the center of which the lower end of the spindle I is guided, and free to move vertically. If preferred, the rod or spindle I may be dispensed with, the upper end of the spring H being turned up to bear directly against the lever, whilst the lower end may either lay in a sunk bed in the cross-head, or be turned down to form a contact or centre-bearing point.

Figure 4* is a detail showing another modification of the mode of fitting or adapting the spring or springs H. *a* is the bent end of the lever E shown in figure 1; *b* is a nipple or centre point, which is pressed against the end *a* of the lever by one or more springs H H¹. The lower ends of these springs bear against a similar nipple or centre point *c*, which rests in a countersink in the cross-bar K, or in the end of an adjusting screw *d* passing through the cross-bar, so that by raising or lowering the screw the resistance of the spring or springs may be regulated; L L are two long bolts, which pass down through corresponding sockets M M cast on the valve casing, and through corresponding bolt holes near each end of the cross-bar K, which is thus supported entirely by the two bolts. By tightening more or less the bolts L by their nuts, the spring H may be compressed to any desired extent between the cross-bar K and the collar or flange *b* on the spindle I. The opera-
83 tion of the peculiar bent lever is as follows: So soon as the pressure in the boiler overcomes the resistance of the spring H the valve is lifted, and a certain extra compression is put on the spring. The increasing compression of the spring during the opening of the valve has a tendency, if no compensating means are employed, to check the full opening of the valve so as to afford an escape orifice equal in area to that of the passage A, but by bending down the lever, as shown at *a*, the lifting of the valve tends to draw that end of the lever towards the fulcrum, thereby virtually shortening that end of the lever, consequently the power of the lever to compress the spring is increased in proportion as the valve is elevated, or in other words, the resistance of

the spring is proportionately diminished. When the apparatus is properly constructed, the resistance against the lifting of the valve will be uniform, or nearly so, in whatever position the valve may be.

Figure 5 is a vertical section showing the application of another arrangement of compensating lever and springs to a safety-valve; figure 6 is a sectional plan of the same; and figure 7 is an end view of the apparatus. In this arrangement the bent lever E is continued beyond the valve, as shown at *c*, and through this end of the lever slides freely a rod or spindle, N, provided with a flange or collar, *d*, near its lower end, and with a piston or plunger, O, the latter working steam-tight inside a small cylinder, P. This cylinder is in direct communication through the passage *e* with the interior of the boiler. Q is a helical spring surrounding the rod or spindle N, and pressing at its upper end against the end *c* of the valve-lever E, whilst its lower end abuts against the flange or collar *d*. In all other respects the valve and parts connected therewith are the same as in the arrangement previously described and illustrated by figures 1, 2, 3, and 4, with the exception that in lieu of the bearing-points at the parts above, the lever E is in contact with the spindles G and I; ordinary pin-joints are shown connecting such spindles to the lever. By adopting a vertically-sliding indicator to the rod or spindle N in combination with a properly graduated scale or divided plate, the pressure of the steam in the boiler, per square inch, can be readily indicated. As the pressure increases the piston O rises, and the spring Q is compressed, the upper end of
84 the rod or spindle N working freely through the end *c* of the valve-lever. So soon as the steam attains its regulated maximum pressure the resistance of the spring H against the bent end *a* of the lever E will be overcome by that of the spring Q against the opposite end of the lever, together with the pressure under the valve, and the valve C will consequently open, and will be assisted in its opening by the action of the spring Q, whilst at the same time the increasing resistance of the spring H is compensated by the action of the bent end *a* of the lever hereinbefore described. The spring H should of course be made sufficiently strong to resist the regulated pressure upon the area of the valve C as well as the pressure of the spring Q, so as to allow the steam to escape at its maximum pressure only. Figures 1, 2, and 3, on sheet 2 of my drawings, represent similar views of a similar arrangement of compensating safety-valve lever to that illustrated by figures 5, 6, and 7, already referred to, the only difference being in the means employed for indicating the steam-pressure in the boiler. In this arrangement I have shown the valve C of the ordinary construction, the whole of the escape steam passing upwards. A vertical sliding indicator was hereinbefore described as being employed in connection with the rod or spindle N, but in the arrangement shown on sheet 2 of my drawings I have illustrated a revolving indicator and a circular dial. E is the valve-lever, through the end *c* of which works freely the upper end of the rod or spindle N. This end of the rod has a series of rings, *f*, turned thereon, or is provided with ordinary rack-teeth, which gear into a small spur-pinion, *g*, fast on one end of a short spindle, *h*, which revolves freely in a socket or tubular bearing, *i*, carried by the lever E. To the opposite end of the spindle *h* is fitted an indicator or pointer, *k*, which indicates on the face of the circular dial *l*, secured to the outer end of the socket or tubular bearing, *i* the pressure of the steam, per square inch, inside the boiler. The piston O, in place of being made in one piece with the rod or spindle N, is separate therefrom and presses against the rod by a centre-point arrangement shown

at *m*. The steam-passage *e* leading to the cylinder is curved so as to open laterally from the main thoroughfare A of the valve.

Having now described and particularly ascertained the nature
85 of my said invention, and the manner in which the same is or may be used or carried into effect, I would observe, in conclusion, that what I consider to be novel and original, and therefore claim as the invention secured to me by the hereinbefore in part recited letters patent, is:

First. The general construction and arrangement of compensating safety-valves substantially as hereinbefore described.

Second. The application and use to and in safety-valves of bent levers of the first order acting in combination with a spring or springs, substantially in the manner and for the purpose hereinbefore described.

Third. The use in combination with a spring or springs and bent safety-valve lever of the first order of a cylinder-piston, piston-rod, and additional springs, acting substantially in the manner and for the purpose hereinbefore described.

In witness whereof I, the said William Naylor, have hereunto set my hand and seal the eighteenth day of January, one thousand eight hundred and sixty-four.

WILLIAM NAYLOR. [L. S.]

Exhibit D.—C. W. Tuttle, Examiner.

The U. S. Patent Office to all persons to whom these presents shall come, greeting:

This is to certify that the annexed is a true copy from the records of this office of the letters patent granted Henry Waterman, dated 15th November, 1853, No. 10243, and the certificate of extension.

In testimony whereof I, Samuel S. Fisher, Commissioner of Patents, have caused the seal of the Patent Office to be hereunto affixed this twentieth day of January, in the year of our Lord one thousand eight hundred and seventy, and of the Independence of the United States the ninety-fourth.

[L. S.] SAMUEL S. FISHER,
Commissioner.

86 No. 10243.

The United States of America to all to whom these letters patent shall come:

Whereas Henry Waterman, of Hudson, New York, has alleged that he has invented a new and useful improvement in safety-valves for locomotive engines, which he states has not been known or used before his application; has made oath that he is a citizen of the United States; that he does verily believe that he is the original and first inventor or discoverer of the said improvement, and that the same hath not, to the best of his knowledge and belief, been previously known or used; has paid into the Treasury of the United States the sum of thirty dollars, and presented a petition to the Commissioner of Patents, signifying a desire of obtaining an exclusive property in the said improvement, and praying that a patent may be granted for that purpose:

These are, therefore, to grant, according to law, to the said Henry Waterman, his heirs, administrators, or assigns, for the term of fourteen years from the fifteenth day of November, one thousand eight

hundred and fifty-three, the full and exclusive right and liberty of making, constructing, using, and vending to others to be used the said improvement, a description whereof is given in the words of the said Waterman in the schedule hereunto annexed, and is made part of these presents.

In testimony whereof I have caused these letters to be made patent, and the seal of the Patent Office has been hereunto affixed.

Given under my hand at the city of Washington this fifteenth day of November, in the year of our Lord one thousand eight hundred and fifty-three, and of the Independence of the United States of America the seventy-eighth.

[L. S.] ROBERT McCLELLAND,
Secretary of the Interior.

Countersigned and sealed with the seal of the Patent Office.
C. MASON, *Commissioner of Patents.*

87 The schedule referred to in these letters patent, and making part of the same.

To all whom it may concern:

Be it known that I, Henry Waterman, of the city of Hudson, county of Columbia, State of New York, have invented a new and improved mode of constructing the safety-valves of locomotive-engines, and I do hereby declare that the following is a full and exact description thereof, reference being had to the accompanying drawings and letters of reference marked thereon.

Owing to the jolting of the locomotive-engine, when in motion, it was found necessary at an early day to discard the use of the simple weight upon the lever of the safety-valves, as large portions of steam would be blown off when the pressure was below the point indicated by the mean pressure of the weight upon the valve, as, for instance, when the boiler was suddenly thrown upward the weight would continue to go up, so that by the recoil and momentum the valve would be a portion of the time raised from its seat, and the steam allowed to blow off when below the desired point of pressure; the spring-balance was substituted and has been generally used or applied to the lever of safety-valves.

It has been long known that the spring-balance is an imperfect indication of the pressure of steam from the following causes:

The safety-valve, in raising, will raise the outer end of the lever that rests upon, though a much greater distance than the valve itself, as the proportions of power of the lever, as, for instance, a lever of a power of twelve times, resting on a valve, say two inches in diameter, when the valve is raised to its full capacity, say one-half inch, will raise its outer end six inches, a distance quite impossible with an ordinary spring-balance, without greatly increasing the pressure balance, consequently at the same time increasing the pressure of the steam, so that it will be seen an adequate discharge cannot take place with a spring-balance resting upon. Taking another instance: Suppose a valve to raise one-eighth of an inch, which allows an escape of about one-fourth the capacity of the valve, the outer end of the lever will raise one and a half inches. If to this a spring-balance is attached, with a scale of
88 one-twentieth of an inch to the pound, it is evident that the pressure will be increased thereby thirty pounds per inch. To remedy this difficulty I propose to use the simple weight and lever, so as to attain, as near as possible, a constant and uniform pressure upon the

valve, and in order to prevent the vibrations of the weight and lever I apply to outer end of lever a rod that descends vertically, by which the weight is suspended to lever; at the bottom of said rod, below the weight, attach a small piston of about three inches diameter; surrounding this piston I place a cylinder, in which this piston is allowed to move freely and easily; the cylinder is firmly attached to boiler or other convenient parts; into this cylinder I put a fluid—mercury, oil, alcohol, or water. I prefer good sperm oil. This fluid must fill the cylinder to near the top, so as to completely cover the piston. It is evident that the piston can move no faster than the fluid is made to pass by the piston, and that it will check all sudden vibrations, yet freely pass to a position due to pressure, &c. By having an adequate facility of discharging surplus steam we have succeeded in securing an uniform temperature and pressure in the locomotive-boiler, preventing almost entirely the difficulty of leakage of tubes, riveted joints, so commonly caused by these variations; also design it as a sure preventive of explosion from these causes.

Description of drawing.

A represents the rear part of the boiler.
B the ordinary safety-valve.
C the ordinary lever.
D the weight.
E the rod upon which the weight is suspended to lever.
F the piston attached to rod E.
G the cylinder in which the piston F is allowed to move freely.
H is a stand, by means of which the cylinder is attached to boiler A.
I I I I represents the fluid in cylinder G which covers the piston F.

What I claim as my improvement, and desire to secure by letters patent, is the piston F, attached to the weighted end of the valve-
89 lever within the cylinder G, and immersed in the liquid in the cylinder, combined and operating in the manner and for the purposes herein described.

HENRY WATERMAN.

Witnesses:
DARIUS PECK.
JAMES CLARK.

Whereas, upon the petition of Henry Waterman, of Hudson, New York, for the extension of the patent granted to him November 15, 1853, and reissued July 9, 1867, T. C. Theaker, Commissioner of Patents, in accordance with the 18th section of the act of Congress approved the 4th day of July, 1836, entitled "An act to promote the progress of the useful arts and to repeal all acts and parts of acts heretofore made for that purpose," and the act approved the 27th day of May, 1848, "An act to provide additional examiners in the Patent Office and for other purposes," did, on the 13th day of November, 1867, decide that said patent ought to be extended:

Now, therefore, I, Alexander M. Stout, Acting Commissioner of Patents, by virtue of the power invested in the Commissioner of Patents by said acts of Congress, do renew and extend the said patent, and certify that the same is hereby extended for the term of seven years from and after the expiration of the first term, viz, from the 15th day of November, 1867, which certificate being duly entered of record in the Patent Office, the said patent has now the same effect in law as though the same had been originally granted for the term of twenty-one years.

In testimony whereof I have caused the seal of the Patent Office to be hereunto affixed this 26th day of March, 1868, and of the Independence of the United States the ninety-second.

[L. S.] A. M. STOUT,
Acting Commissioner.

Exhibit E.—C. W. Tuttle, Examiner.

The U. S. Patent Office to all persons to whom these presents shall come, greeting:

This is to certify that the annexed is a true copy from the records of this office of the reissued letters patent granted Henry Waterman, dated 9th July, 1867, No. 2675.

In testimony whereof I, Samuel S. Fisher, Commissioner of Patents, have caused the seal of the Patent Office to be hereunto affixed this twentieth day of January, in the year of our Lord one thousand eight hundred and seventy, and of the Independence of the United States the ninety-fourth.

[L. S.] SAMUEL S. FISHER,
Commissioner.

Reissue No. 2675.

The United States of America to all to whom these letters patent shall come:

Whereas Henry Waterman, of Hudson, N. Y., has alleged that he has invented a new and useful improvement in safety-valves (for which letters patent were issued to him dated Nov. 15, 1853, which letters being surrendered by him, the same have been cancelled and new letters ordered to issue to him on an amended specification), which he states has not been known or used before such invention; has made oath that he is a citizen of the United States; that he does verily believe that he is the original and first inventor or discoverer of the said improvement, and that the same hath not, to the best of his knowledge and belief, been previously known or used; has paid into the Treasury of the United States the sum of thirty dollars, and presented a petition to the Commissioner of Patents praying that a patent may be issued therefor:

These are therefore to grant, according to law, to the said Henry
91 Waterman, his heirs, administrators, or assigns, for the term of fourteen years from the fifteenth day of November, one thousand eight hundred and fifty-three, the full and exclusive right and liberty of making, constructing, using, and vending to others to be used, the said improvement, a description whereof is given in the schedule hereunto annexed, and made part of these presents.

In testimony whereof I have caused these letters to be made patent, and the seal of the Patent Office to be hereunto affixed.

Given under my hand, at the city of Washington, this ninth day of July, in the year of our Lord one thousand eight hundred and sixty-seven, and of the Independence of the United States of America the ninety-second.

[L. S.] W. T. OTTO,
Acting Secretary of the Interior.

Countersigned and sealed with the seal of the Patent Office.
T. C. THEAKER,
Commissioner of Patents.

UNITED STATES PATENT OFFICE.

Henry Waterman, of Hudson, New York. Letters patent No. 10243, dated November 15, 1853; reissue No. 2675, dated July 9, 1867. Improvement in safety-valves.

The schedule referred to in these letters patent and making part of the same.

To all whom it may concern:

Be it known that I, Henry Waterman, of Hudson, in the county of Columbia, in the State of New York, have invented a new a' useful improvement on the safety-valve for steam-generators, and I do hereby declare that the following is a full, clear, and exact description of the construction and operation of the same, reference being had to the annexed drawings, making a part of this specification, in which—

A represents a vertical section of part of the boiler.

92 B represents a vertical section of the valve.

C the ordinary lever.

D the weight.

E the rod upon which the weight is suspended.

F the piston attached to the rod E.

G the cylinder in which the piston F moves freely.

H is a stand, by means of which the cylinder is attached to the boiler or other permanent support.

I I I I represent the fluid in the cylinder G which covers the piston F.

k k represent the overhanging part of the valve, which increases its area outside of and beyond the ground joint.

l l represent a concentric rim or ledge that directs the steam upwards against the overhanging part *k k*, by means of which the valve is assisted in rising.

In the ordinary safety-valve of steam-generators it has long been known that there existed a strong inclination or attraction between the valve and the seat, other than that produced by the superincumbent weight or force; or, in other words, when the valve is loaded so that the steam shall commence to escape from the generator at a given density or pressure of the steam, it requires a greatly increased force against the valve to raise it to a distance from the seat that will allow any near approach to the full capacity of the valve for effecting the escape of steam. This is true when the superincumbent force is constant, as in the case when a weight is used; it is still more forcibly felt when the superincumbent force is a spring, as is the case in all locomotive engines, for the reason that the force of the spring increases as it is moved. I construct the safety-valve of steam-generators so that the aforementioned disposition shall be counteracted, and its evil effects entirely prevented. I desire to use a weight, whenever it is possible, for the reason that the force due to its gravity is constant. The weight is generally used with the generators of stationary and steamboat engines. In the case of locomotive engines, however, their jolting, when in motion, causes the valve (when a weight is used) to jump up from its seat before the steam has attained sufficient density or pressure to raise it. To

93 counteract this jolting, jumping, tendency, I attach to the weight a piston, working in a liquid dash-pot. This will only prevent the jolting tendency, however. Another contrivance is necessary to counteract the disposition of the valve to stick or be attracted to the

seat. For this purpose I construct the valve and seat so that the escaping steam shall act upon an increased area of the valve after it has raised from its seat, or, in other words, so that, when the valve has raised from its seat, the escaping steam is so directed that its force strikes an overhanging or projecting annular surface on the top of the valve, and outside of and beyond the ground joint. Thus, in the drawing, *k k* indicates this overhanging or projecting annular surface, while *l l* indicates a concentric rim or ledge, so constructed as to turn the force of the escaping steam against *k k*. This force may be modified by a proper modification of the overhanging or projecting annular surface; thus, if the overhanging surface be large, the force of the steam will suddenly open the valve and discharge so much steam that the pressure in the generator will be considerably reduced before the valve closes. This overhanging surface *k k* may, however, be made so small that but little more than the surplus steam actually generated will escape. In either case, besides overcoming the sticking or attraction of the valve to the seat, this most desirable object will be attained, to wit, the steam pressure in the generator will not rise a particle above the initial point of escaping. The peculiarity of this form of valve is this, that while it prevents the steam from rising above the initial point of blowing, the valve will remain open until the pressure is reduced below the initial point of blowing before it will be allowed to close, the success or efficiency of it must depend upon a proper proportion of the parts *k k* and *l l*; thus, if those parts are of large proportion and the steam allowed a free discharge between them, it will not at all assist the valve in rising. Again, if they are made too large and the escape between them be too small, it will cause the valve to rise too easily and remain open too long, so that the steam will be so much reduced in pressure as seriously to impair their economical and efficient condition. It has been found in practice, for instance, that in case of a safety-valve, such as is
94 usually used in the locomotive engines, of about two and a half inches in diameter, with a pressure of steam about one hundred and thirty pounds per square inch, if the overhanging part *k k* is made of a diameter of about one-sixth of an inch, on each side, larger than the valve proper, and the ledge or rim *l l* is made of a diameter about one-sixteenth, on each side, larger than *k k*, so as to leave an opening of about one-sixteenth of an inch in space between the parts *k k* and *l l*, and the part *k k* is made to sink down into the cavity formed by the parts *l l* about one-sixteenth of an inch, the valve will rise, and will discharge the steam freely, until the pressure is reduced about three pounds per inch below the initial point of blowing, which I consider a most desirable and efficient operation; these being the proportions when the pressure is used of different density, until a small margin of difference is obtained between the opening point of pressure and the closing. Thus it will be seen that when it is ascertained that the generator has sufficient strength to bear with perfect safety a given load of pressure, the use of this valve will not allow the pressure to exceed that point, when the valve has been gauged to said point. Boiler-explosions, caused by excessive pressure, will therefore be entirely prevented, and boiler-leakage, caused by great variations of pressure and temperature, will also be prevented.

The operation of this contrivance is as follows:

As before stated, I prefer, in order to attain a most perfect action, to use as a superincumbent force a weight which will put upon the valve a steady, uniform force, which will not increase as it is raised; and to counteract any jolting tendency, I use the piston F, working in the cyl-

inder G, immersed in the I I I I. It is evident that the piston cannot move in the cylinder without requiring the fluid to pass from one side of the piston to the other. I make the piston sufficiently small, so that it will not only move without touching the sides of the cylinder, but will allow the fluid to pass slowly, yet freely. Thus it will be seen that the piston will move slowly to its proper position, avoiding any sudden motion caused by jar or jolting. Then when the steam has been raised to a point that, by its pressure upon the lower side of that portion of the valve within the area of the opening through the seat, it is
95 enabled to raise the superincumbent weight, it will allow the steam to escape. This escaping steam is then, by the concentric rim or ledge *l l*, directed upward against the enlarged area of the valve made by the overhanging part *k k*, the comparative size of which must be such, and the size of the orifice made by the approach of the parts *k k* and the parts *l l* must also be such, as to form a sufficient retardment of the escaping steam, or just sufficiently to raise the valve and counteract the sticking tendency of the valve before mentioned, for, as before mentioned, when the valve is assisted too much by the improper proportion of these parts, the valve will stay open too long, the steam will escape until it will be too much reduced in pressure. This action will defeat the object I have in view, which is to keep the pressure of the steam as near as possible the initial point of blowing, and not allow it to go above that point, and not to escape materially below it.

What I claim as my invention, and desire to secure by letters patent is—

1. The piston F, attached to the weighted end of the valve-lever within the cylinder G, and immersed in the liquid in the cylinder, combined and operating in the manner and for the purpose herein described.

2. I also claim the concentric rim or ledge *l l* and the overhanging part of valve *k k*, constructed, combined, and operating in the manner and for the purpose herein set forth.

HENRY WATERMAN.

Witnesses:
GEO. W. RICHARDSON,
W. H. POOR.

Exhibit F.—C. W. Tuttle, Examiner.

The U. S. Patent Office to all persons to whom these presents shall come, greeting:

96 This is to certify that the annexed is a true copy from the records of this office of the letters patent granted George W. Richardson, dated 25th September, 1866, No. 58294.

In testimony whereof I, Samuel S. Fisher, Commissioner of Patents, have caused the seal of the Patent Office to be hereunto affixed, this fourth day of May, in the year of our Lord one thousand eight hundred and sixty-nine, and of the Independence of the United States the ninety-third.

[L. S.] SAMUEL S. FISHER,
Commissioner.

No. 58294.

The United States of America to all whom these letters patent shall come:

Whereas George W. Richardson, of Troy, New York, has alleged

that he has invented a new and useful improvement in steam safety-valves, which he states has not been known or used before his application; has made affirmation that he is a citizen of the United States; that he does verily believe that he is the original and first inventor or discoverer of the said improvement, and that the same hath not, to the best of his knowledge and belief, been previously known or used; has paid into the Treasury of the United States the sum of thirty-five dollars, and presented a petition to the Commissioner of Patents, signifying a desire of obtaining an exclusive property in the said improvement, and praying that a patent may be granted for the purpose:

These are therefore to grant, according to law, to the said George W. Richardson, his heirs, administrators, or assigns, for the term of seventeen years from the twenty-fifth day of September, one thousand eight hundred and sixty-six, the full and exclusive right and liberty of making, constructing, using, and vending to others to be used, the
97 said improvement, a description whereof is given in the words of the said George W. Richardson, in the schedule hereunto annexed, and is made part of these presents:

In testimony whereof I have caused these letters to be made patent, and the seal of the Patent Office has been hereunto affixed.

Given under my hand at the city of Washington this twenty-fifth day of September, in the year of our Lord one thousand eight hundred and sixty-six, and of the Independence of the United States of America the ninety-first.

[L. S.]

W. T. OTTO,
Acting Secretary of the Interior.

Countersigned and sealed with the seal of the Patent Office.

T. C. THEAKER,
Commissioner of Patents.

The schedule referred to in these letters patent and making a part of the same.

To all whom it may concern:

Be it known that I, George W. Richardson, of the city of Troy, in the county of Renssalaer, in the State of New York, have invented a new and useful improvement on a safety-valve for steam-generators; and I do hereby declare that the following is a full, clear, and exact description of the construction and operation of the same, reference being had to the annexed drawings, making a part of this specification, in which—

Fig. 1 is an end view of my improved safety-valve and its seat as seen from the bottom.

Fig. 2 is an end view of the valve alone as seen from the bottom.

Fig. 3 is a vertical section, at *x x*, Fig. 1, of the valve and seat in position.

Fig. 4 is a vertical section, at *y y*, Fig. 2, of the valve alone. Similar colors and letters of reference indicate corresponding parts in the several figures.

A A is the head of the safety-valve.

B B B B are wings to guide the valve into its seat E E.

98 *c c* is a circular or annular flange or lip extending over, slightly below, and fitting loosely around the outer edge of the valve-seat E E.

D D is a circular annular chamber, into which the steam immediately passes when the valve lifts from its seat at the ground joint F F.

E E is the valve-seat.

F F is the ground joint of the valve and seat.

P is the countersink or centre upon which the point of the stud extending from the scale-lever rests in the usual manner.

The nature of my invention consists in increasing the area of the head of the common safety-valve outside of its ground joint, and terminating it in such a way as to form an increased resisting surface, against which the steam escaping from the generator shall act with additional force after lifting the valve from its seat at the ground joint; and so, by overcoming the rapidly-increasing resistance of the spring or scales, insure the lifting of the valve still higher, thus affording so certain and free a passage for the steam to escape as effectually to prevent the bursting of the boiler or generator, even when the steam is shut off and damper left open.

To enable others skilled in the art to make and use my invention, I will proceed to describe its construction and operation. To the head of the common safety-valve, indicated by all that portion of Fig. 2 lying within the second circle from the common centre, I add what is indicated by all that portion lying outside of the said circle, in about the proportion shown in the figure. A transverse vertical section of this added portion is indicated, in Fig. 4, by those portions of the figure lying outside of the dotted lines *p p*, *p p*, while all that portion lying within the dotted lines *p p*, *p p* indicates a transverse vertical section of the common safety-valve alone. This increased area may be made by adding to a safety-valve already in use, or by casting the whole entire.

I terminate this addition to the head of the valve with a circular or annular flange or lip *c c*, which projects beyond the valve-seat E E, Fig. 3, and extends sightly below its outer edge, fitting loosely around it and forming the circular or annular chamber D D, whose transverse
99 section, shown in the figure, may be of any desirable form or size.

This flange or lip *c c*, fitting loosely around the valve-seat E E, is separated from it by about $\frac{1}{64}$th of an inch for an ordinary spring or balance. For a strong spring or balance this space should be diminished, and for a weak spring or balance it should be increased to regulate the escape of the steam as required. Instead of having the flange or lip *c c* project beyond, and extend below and around the outer edge of the valve-seat, as shown in Fig. 3, a similar result may be attained by having the valve-seat itself project beyond the outer edge of the valve-head and terminating it with a circular or annular flange or lip, extending slightly above and fitting loosely around the outer edge of the flange or lip *c c* of the valve-head; but I consider the construction shown in Fig. 3 preferable.

With my improved safety-valve, constructed as now described and attached to the generator in the usual way, the steam escaping in the direction indicated by the arrows in Fig. 3 first lifts the valve from its seat at the ground joint E F, and then passing into the annular chamber D D, acts against the increased surface of the valve-head, and by this means, together with its reaction produced by being thrown downwards upon the valve-seat F E, it overcomes the rapidly increasing resistance of the spring or balance, lifts the valve still higher, and escapes freely into the open air until the pressure in the generator is reduced to the degree desired, when the valve will be immediately closed by the tension of the spring or balance. The escape of the steam, by means of this safety-valve, is so certain and free, that the pressure of the steam in the generator or boiler will

not increase beyond the point or degree at which the valve is set to blow off.

What I claim as my improvement, and desire to secure by letters patent, is a safety-valve with the circular or anular flange or lip *c c*, constructed in the manner, or substantially in the manner, shown, so as to operate as and for the purpose herein described.

GEORGE W'M RICHARDSON.

Witnesses:
GEO. GOULD.
W'M H. POOR.

100 *Exhibit K.—C. W. Tuttle, Examiner.*

The United States Patent Office to all persons to whom these presents shall come, greeting:

This is to certify that the annexed is a true copy from the records of this office, of the specification and drawing of the letters patent granted W. Naylor, October 16th, 1866, 58962.

In testimony whereof I, T. C. Theaker, Commissioner of Patents, have caused the seal of the Patent Office to be hereunto affixed this sixth day of May, in the year of our Lord one thousand eight hundred and sixty-seven, and of the Independence of the United States the ninety-first.

[L. S.] T. C. THEAKER.

No. 58962.

William Naylor, of Lorn Terrace, Mildmay Park, England. Letters Patent No. 58962, dated October 16, 1866. Improvement in Steam Safety-Valves.

To all whom it may concern

Be it known that I, William Naylor, of Lorn Terrace, Mildmay Park, in the county of Middlesex and Kingdom of Great Britain, have invented certain new and useful improvements in safety-valves, and I hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawing.

This invention relates to spring safety-valves, and is applicable to locomotive-engine boilers and stationary and marine engine boilers. The main object to be attained by this invention is the counteracting the additional load upon the valve as it is raised from its seat, produced by the increased resistance of the spring. This is accomplished by using a lever of the first order, one end resting by a suitable pin
101 upon the safety-valve, and the other end of the lever resting upon the spring, but in lieu of having this lever straight or nearly so, I propose to bend downwards that end which is acted upon by the spring to an angle of about 45°, so that when the valve is raised by the steam the other end of the lever is depressed upon or against the spring downwards, and at the same time is moved inwards towards the fulcrum, thus virtually shortening that end of the lever, and thereby counteracting the additional load upon the valve as it is raised from its seat by the greater amount of compression or tension (as the case may be) which is put upon the spring.

Figs. 1 and 2 of the annexed sheet of drawings represent respectively a vertical section and front elevation of a safety-valve, constructed ac-

cording to my invention. A is the main thoroughfare, leading direct from the boiler B, a lateral branch or escape passage for a portion of the steam after it has passed the valve C. I prefer to make this valve project over the edges of the exit-passage A, and to curve the projecting edges of the valve slightly downwards, as shown in Fig. 1, so that the steam on issuing between the valve and its seat will impinge against the curved projecting portion of the valve, and a portion of it will be directed downwards into the annular chamber D, surrounding the central passage A, and communicating with the exit-pipe B, whilst the other portion of the steam ascends past the edge of the valve. E is my improved valve-lever working on a fulcrum, F, and made to hold down the valve at one end through the rod or spindle G, by the expansive force of the helical spring H, which exerts an upward pressure against the opposite end *a* of the lever. This end *a* of the lever is bent downwards to an angle of about 45°, and is acted upon directly by the upper end of a rod or spindle, I, situated inside the coils of the spring H, and provided with a flange or collar, *b*, against which the upper end of the spring bears, the lower end of the spring resting upon a cross-bar, K, through a hole in the centre of which the lower end of the spindle I is guided, and is free to move vertically. If preferred the rod or spindle I may be dispensed with, the upper end of the spring H being turned up to bear directly against the lever, whilst the lower end may either lay in a sunk bed in the cross-head or be turned down to form a
102 contact or centre-bearing point. Fig. 3 is a detail showing a slight modification of the mode of fitting or adapting the spring or springs H. *a* is the bent end of the lever E shown in Fig. 1. *b* is a nipple or centre point, which is pressed against the end *a* of the lever by one or more springs, H H¹. The lower ends of these springs bear against a similar nipple or centre point, *c*, which rests in a countersink in the cross-bar K, or in the end of an adjusting screw, *d*, passing through the cross-bar, so that by raising or lowering the screw the resistance of the spring or springs may be regulated. L L (Fig. 2) are two long bolts passing through corresponding sockets M M, cast on the valve-casing and through corresponding bolt-holes near each end of the cross-bar K, which is thus supported entirely by the two bolts. By tightening more or less the bolts L by their nuts, the spring H may be compressed to any desired extent between the cross-bar K, and the collar or flange *b* on the spindle I. The operation of the peculiar bent lever is as follows: So soon as the pressure in the boiler overcomes the resistance of the spring, H, the valve is lifted and a certain extra compression is put on the spring; the increasing compression of the spring during the opening of the valve has a tendency, if no compensating means are employed, to check the full opening of the valve, so as to afford an escape-orifice equal in area to that of the passage A; but by bending down the lever, as shown at *a*, the lifting of the valve tends to draw that end of the lever towards the fulcrum, thereby virtually shortening that end of the lever, consequently the power of the lever to compress the spring is increased in proportion as the valve is elevated, or in other words the resistance of the spring is proportionately diminished. When the apparatus is properly constructed the resistance against the lifting of the valve will be uniform, or nearly so, in whatever position the valve may be. Fig. 4 represents a vertical section of a two-inch locomotive-boiler safety-valve, wherein the spring operates by tension in lieu of by compression, as in the previous arrangement. The same letters of reference indicate the corresponding parts to those shown in Figs. 1 and 2. A is the main thoroughfare from the boiler; B

is the exit-pipe for the escape steam; C the valve itself, which is
103 held down by one end of the lever E working on the fulcrum F, and bearing at one end upon a rod or spindle, G, whilst its opposite end is bent downwards as shown at *a*, and is connected by the knife-edged link I with the lower end of the helical spring H, to which the link is hooked; the upper end of this spring, which is enclosed in a tubular casing H^1, is hooked into the adjustable eye K, carried by the lower end of the adjustable screw-spindle L, which passes through a central aperture in the top of the casing, and is prevented from rotating by a key fitting a slotted key-way extending longitudinally down one side of the screw-spindle. M is a nut or hand-wheel working on the screw-spindle, by turning which the screw will be raised or lowered, and consequently more or less tension will be put upon the spring, and a corresponding load applied to the valve-lever E. N is a circular knife-edged index secured to the top of the screw-spindle, and O is the graduated scale attached to the nut or hand-wheel for indicating the load upon the valve per square inch.

The valve on being lifted will elevate the corresponding end of the bent lever E, and depress the opposite or bent end *a*, which will be more or less resisted by the contractile power of the spring H, but the end *a*, on being depressed, will at the same time be drawn towards the fulcrum, thereby virtually shortening that end of the lever and compensating for the increased resistance of the spring. When the collar of K reaches the top of the casing no further load can be put on the valve, and thus any tampering with the valve is prevented. Fig. 5 represents a vertical section of a portion of a five-inch safety-valve, adapted for large marine or land boilers, constructed according to this invention. It is similar in all essential details to the smaller arrangements illustrated by Fig. 4, and the corresponding parts are indicated by corresponding letters of reference. In safety-valves for marine boilers, I prefer, however, to close steam-tight the bottom of the casing containing the helical spring H, by *any* means of a flexible diaphragm P, of vulcanized India rubber or other suitable material capable of withstanding the action of steam, whereby all access to the spring of salt water thrown through the safety-valve when priming, and the injurious effect thereof upon the metal, is prevented. This diaphragm is held at its circumference between the
104 flanges of the spring-casing and the valve-casting, whilst its centre is nipped between the annular end *e* of the link I and the shoulder *f*, which shoulder has a square or hexagonal central boss, *g*, formed thereon, and fitting a correspondingly shaped aperture in the top of the link I. *h* is a nut working on a screw in the centre of the boss *g*, and serving to nip the diaphragm between the parts *e f*. The valve-casing is of cast iron, and the valve and seat are of gun-metal. Q is a small relieving lever for easing the valve when requisite, its inner end projecting beneath the end of the safety-valve lever, as shown, whilst its outer end is connected to a rod for actuating the relieving lever.

Claim.

The arrangement substantially as hereinbefore shown and described in safety-valves of bent levers of the first order, acting in combination with a spring or springs, the whole operating in the manner and for the purpose set forth.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

W'M NAYLOR.

Witnesses:
EDWARD P. ALEXANDER.
JOHN J. VIDLER.

105 EVIDENCE FOR RESPONDENT CONTINUED.

Taken pursuant to the 67th rule of the Supreme Court of the United States, in equity, as amended, before me.

JOHN G. STETSON,
Examiner.

Deposition of George W. Richardson.

APRIL 30, 1872.

Direct examination by Benjamin Dean, esq., of counsel for respondent:

Int. 1. State your name, age, residence, and occupation.

Ans. George W. Richardson; 43; Troy, N. Y.; machinist and engineer; machinist is my regular trade. I have been a locomotive engineer. I am the inventor of the Richardson valve, patented Sept. 25, 1866. Exhibit F is a copy of my patent, and Exhibit No. 2 is one of my patented valves.

Int. 2. When did you first invent said valve?

Ans. In the winter of 1851–'2.

Int. 3. What did you then do about it?

Ans. I made some drawings of the valve, sketches, and that is all I did about it then.

Int. 4. Did you make any model of it at any time? If yes, when?

Ans. I did. In the spring of 1852 I made a sectional model for explanation to my father and brother and Marcus P. Norton, for the purpose of getting help to get a patent on the same. This was in
106 my father's cabinet-shop in Poultney, Vermont. I made a sectional model, cut it out of veneer, to explain more fully the action of the valve. Afterwards I turned a model of wood to show to the same parties. Norton at that time was getting a model made for obtaining a patent for himself in my father's shop, and he claimed to be worth money, and would help me at some time to obtain a patent. He never did help me. My brother was working in the shop on musical instruments, reed organs, and doing painting, job work. My father died in May, I think, 1861. I tried to get my brother to assist me with money in obtaining a patent at that time and at different times afterwards, but I could not make him see the benefit of the invention, or he thought he could not make anything out of it, and declined assistance. My attention was first called to it by the escaping steam of a small engine coming out with a sharp, hissing sound, and when I raised the lever with my hands it would escape more freely and finally close. At that time I had been married two years, had one child, owned a small house that I had paid about one hundred and fifty or two hundred dollars upon, and I was working for H. J. Ruggles as a machinist, in Poultney, Vermont, at one dollar and fifty cents a day.

Int. 5. Did you make any other efforts to obtain aid in patenting your invention? If yes, what, and how did you succeed?

Ans. I did ask one other person to help, Ralph Richards; but as he was a farmer he did not wish to engage in the busines . I did at differ-

ent times afterwards, ask different persons. I remember Jonas Wilder, for one, superintendent of the Rutland & Washington R. R.; and Isaac V. Baker, superintendent of the Troy & Boston R. R., afterwards. I can't tell the precise time; it was about between 1858 and 1861, about that time. I couldn't make them appreciate the invention at all. I tried Mr. Baker to let me put one on, but he replied that they were so short of engines at that time that he didn't want one laid up for an experiment. After the time to 1865, it was in the fall or winter of 1865, I met William H. Poor, of Poultney, V't, I think. He was engaged in a patented invention, and I had been at work on it. I met him in the cars, between Troy and Poultney, V't. Our conversation was
107 upon inventions. I told him I had an invention which was far better than the one he was engaged in, but I couldn't get help to get a patent on it. He said if I could show him the invention, if it was valuable he would assist me. I got a man in the shop to work nights with me and make a safety-valve, and got permission to put it on if I would not detain the engine. I did put it on at night and it worked satisfactorily and was identical with the Exhibit No. 2, with the exception of the rim or cup in the bush outside of the valve-seat—the entire outer edge of Exhibit 2—which entire outer edge was supplied or made unnecessary by a copper escape-pipe turning the steam upward.

Int. 6. How did the drawings and models you have spoken of compare with your valve as now constructed?

(Objected to, no foundation being laid for the admission of secondary evidence.)

Int. 7. What became of the drawings and models you have spoken of?

Ans. They were left in my father's shop, and I could never find them, although I have searched for them. Never thinking I should want those particular models, I have never found them since he died. The house and shop were sold at auction and the shop converted into a dwelling. I was at work on the Troy and Boston R. R. almost night and day, just as long as it was possible for a man to work, and did not have time to look over even to get my own tools that were in the shop.

Int. 7. Now please answer interrogatory 6.

Ans. The valve was the same with the seat flanged and the part under the valve raised, same as valve and seat in Exhibit 2, except the outer edge, which was about one inch from the edge of the valve.

Int. 9. Did you receive any assistance from M'r Poor?

Ans. I did; such assistance as would enable me to pay the man that worked with me and all expenses connected.

Int. 10. Did you make any other models than those you have mentioned prior to your conversation with M'r Poor?

Ans. I think I did make some paper sectional models to show M'r Poor—cut them out of paper or pasteboard—and afterwards a
108 brass one. I didn't understand the question as to the word "prior." I do not recollect of any prior.

Int. 11. Had you means of your own sufficient prior to your conversation with M'r Poor?

Ans. I had not. My wife was an invalid, and it took all I could earn to live.

Int. 12. Had you seen or known of any other valve like yours prior to your patent?

Ans. I had not.

Int. 13. Or since?

Ans. I have seen them since. I see one here. (Witness points to a valve marked "Plaintiff's Exhibit A, C. W. T., Examiner," George W.

Richardson v. Edward H. Ashcroft.) I have only known of M'r Ashcroft's, that was just the same as mine. I cannot tell the exact date when I first heard of Ashcroft's being like mine; some year and a half ago or two years, I should think it was, when my partner wrote M'r Ashcroft in regard to it.

Int. 14. Had you received any messages or communications from M'r Ashcroft prior to that time? If yes, what?

Ans. I had in writing. I will produce them.

Int. 15. Look at Defendant's Exhibit G, in this case, and state what it is.

Ans. I should say it was a Naylor safety-valve, with the exception of the bent lever, in this case the spring being directly on the valve, with no leverage.

Int. 16. How does it compare with the description in the Naylor patent?

Ans. I think it compares exactly with figures 1 and 2 of the Naylor patent, Exhibit K, with the exception of the spring and bent lever. This Exhibit G has the spring directly on the valve, while in figures 1 and 2 it has a bent lever between the valve and spring to assist the valve in raising while it is blowing off steam, as described and shown in the specification and drawings of the Naylor patent of Oct. 16, 1866.

109 MAY 1, 1872.

On looking at Exhibit No. 1, being reissue No. 3727 to Ashcroft, assignee of Naylor, I find that figures 1 and 2 are the same as figures 1 and 2 of the Naylor patent, Exhibit K, and my answer applies to this patent the same as to Exhibit K.

Int. 17. Have you ever witnessed any experiments with Exhibit G in connection with other valves? If so, what were said experiments?

Ans. I have. The valve was placed on a locomotive-engine at the Boston & Lowell R. R. engine-house in East Cambridge. Steam was raised in the boiler to the pressure of about one hundred pounds, when the valve commenced blowing. The pressure increased to about one hundred and twelve or fifteen pounds, when we were obliged to turn the steam into the tank to keep it from increasing any more. When the pressure was diminished to about ninety-eight or nine, or slightly below the pressure at which it started, the valve closed. The steam went out of the opening of the tin pipe as it is now; that is, with the valve as it is now, with the deflecting lip on. There was a very strong current of air passing through the opening around the edge of the deflecting lip from the top, and when pieces of paper were dropped over the valve they went through the opening with great velocity and out with the steam through the exit tin pipe.

Int. 18. How does your patented valve operate, as compared with Exhibit G, as to the relief to the boiler?

Ans. When my valve commences to blow, it blows hard and suddenly, the valve rising about one-twelfth of an inch on a locomotive; when the steam pressure is diminished slightly below the starting-point it suddenly closes. It suddenly opens and it suddenly closes. The steam never rises above the pressure at which the valve opens. The pressure on Exhibit G increases as in the ordinary safety-valve.

Int. 19. What would be the effect if the bent lever described in Exhibits I and K were applied to your valve?

Ans. By reason of the increased surface for the steam to act against after it left the ground joint, and the compensation for the increased tension of spring, the pressure would probably be reduced

110 from one hundred to about sixty; that is, the pressure would be reduced forty pounds, which would make it worthless.

Int. 20. What would be the effect of said bent lever as applied to valve Exhibit G?

Ans. I think it would make a very good valve.

Int. 21. Why would the effect be so different of said bent lever on Exhibit G?

Ans. What do you mean; different from what?

Int. 22. Different from its effect upon your valve, as you have described it. You say in your valve that the addition of the lever to your valve would make it worthless; its effect upon Exhibit G would make it a good valve.

Ans. Because in Exhibit G the increased tension of the spring is not compensated by the increased size and shape of the valve-head; it simply turns the steam downward to the exit-passage, as indicated by arrow and B in Fig. 1, of the drawing of the Naylor patent, Exhibit No. 1, and would be therefore compensated by the bent lever and spring, as indicated in the same figure; while in my valve the increased tension of the spring is compensated by the annular space or groove formed by the head and seat of the valve, as indicated and drawn in Fig. 3, letter D, in my patent of Sept. 25, 1866, Exhibit F. As my valve raises, the steam issues from the opening of the ground joint F, indicated by arrows in Fig. 3, into the annular chamber or space D, and it expands, or the molecules of the steam are enlarged and the current of steam broken, which have to unite to pass the structure between the edge or lip of valve *c*, and edge of valve-seat or bush E, thus causing an actual pressure outside of the ground joint, to be exerted upward on the valve and downward on the seat, which causes the valve to lift still higher than it would were not said stricture so formed.

Int. 23. Is there anything in the Naylor patent, Exhibit No. 1, like that which you have last described as existing in your valve?

Ans. There is not. There is simply a curved lip to direct the steam downward and through passage B, indicated by arrow in Fig. 1.

Int. 24. Have you ever noticed the force of the mere velocity of steam issuing from a boiler? If yes, describe it.

Ans. I have. I have seen small wheels with fans on for the
111 steam to act against as it issued from the boiler, which would run with great velocity but with very little power. I have, in running a locomotive, frequently put my finger under the gauge-cocks when open. If steam issued there was hardly any force; if water issued it would drive my finger away.

Int. 25. How did you ascertain the extent of the power of issuing steam, if at all, by the fans you have mentioned?

Ans. By running small watch-work with them, with silk threads or bands. There is not enough power in it to be of any mechanical value unless the steam is partially confined, and when so confined the power derived will be in proportion to the confinement.

Int. 26. What are the differences, if any, between your valve and the Waterman valve patented Nov. 15, 1853, Exhibit D?

Ans. The Waterman valve, as drawn in said Exhibit D, works or acts like my valve when first used, but will not last or wear well. The upper corners of the valve and seat wear by the issuing steam, which varies the opening or stricture so that it makes too many repairs necessary for a good valve as mine; while in mine the wear is compensated so nearly, that the valves have been worn entirely through the head without effecting the accuracy in blowing off. The seat F in my valve,

and the lower edge of the lip *e*, wear so nearly equal as to make this perfection. I have known the Waterman valve to get out of order in a very few times blowing, so that the head would have to be enlarged. Probably one month's wear on a locomotive would do it, as a general thing. Mine have lasted, nearly all of them, to this time, except in some instances where there is a great deal of mud in the water in the boiler; I mean from 1865 until now.

Int. 27. What is the office of the outer lip of the valve-seat or bush in Exhibit 2; I mean the outermost part of all which turns up?

Ans. It simply turns the steam upwards so it may not beat down into the cab or jacket of the locomotive-engine.

Int. 28. Did you ever make any valves without it?

Ans. I have manufactured the bushes without it, but in placing
112 them on the dome-cap of engine they were sunk in, as shown in the cut of my circular which I have here.

(Cut in circular produced is marked "Exhibit M, J. G. S., Examiner.")

Where the bush of the valve is marked "B," the dome-cap A forms the outer lip, as in question 27; and *a* in cut, Exhibit M, shows the outer part to be formed of cast iron, as the dome-caps are generally cast. In a few instances I have put them on old-style Hinkley engines without the outer rim, it being formed by copper escape-pipe to turn the steam upwards, which answered all the purposes of the other. I did put them as in cut, Exhibit M, on the first engines to which I applied them, on the New York Central Railroad; also on the Western Railroad; also on the Rutland and Washington Railroad; also the Harlem Railroad. But the labor required to apply or bore out the dome-cap in that form caused me to manufacture the valve and bush as in Exhibit 2, which is the same as in cut, Exhibit M, except the outer lip of one is cast iron.

Int. 29. At the time of your invention and at the time of your applying for a patent, was there anything in use on locomotive-engines for the purpose of turning up the steam as it escaped from safety-valves? If yes, what?

Ans. There was; a ledge or rim; also, in most engines, a copper escape-pipe. I never saw a locomotive equipped without something to perform that office.

Int. 30. Are you now able to produce the communications from M'r Ashcroft about which you have been interrogated? If yes, please produce them and any answer to them, any letter from you to him, a copy of which you may have.

Ans. I have, and I produce them, with a copy of a letter from G. W. Richardson & Co. to M'r E. H. Ashcroft.

(Letter produced, dated May 14, 1868, marked "Exhibit N, J. G. S., Examiner," and envelope enclosing same, marked "Exhibit N^1, J. G. S., Examiner." Letter produced, dated April 28, 1868, marked "Exhibit O, J. G. S., Examiner," and envelope enclosing same, marked "Exhibit O^1, J. G. S., Examiner." Copy of letter produced, dated May 12, 1858, marked "Exhibit P, J. G. S., Examiner."

Objected to as irrelevant.)

113 Int. 31. Did you about the same time receive any other letter, the handwriting of which is similar to the directions on the envelopes of the two letters you have produced?

Ans. I did. I produce it.

(Letter produced, dated May 4, 1868, marked "Exhibit Q^1, J. G. S., Examiner," and envelope enclosing same, marked "Exhibit Q, J. G. S., Examiner."

Objected to as irrelevant.)

Int. 32. When did you begin to actively introduce your valve into use?

Ans. In the summer of 1866. I began to put them on as many engines as I could, conveniently, for trial.

Int. 33. How were your valves received by railroad men?

Ans. They liked them very well, and it took all my time after Jan. or Feb., 1867, to supply all the demand. They were called the best valve in use. The demand has been constantly increasing. Railroad companies have been putting them on besides what I have made; builders also. It has taken the place of other valves to a very great extent.

Int. 34. Has it acquired any popular name among railroad men? If yes, what, and from what cause?

Ans. I don't know as I fully understand the question. I don't know of any popular name except Richardson's safety-valve; it is popular among railroad men.

Int. 35. Have you heard it called the "pop valve?" If so, from what cause?

Ans. I have heard railroad men call it the pop valve, because it blows off suddenly and closes suddenly.

Int. 36. From the time of your invention up to your applying for a patent by M'r Poor's assistance, did you at any time abandon the idea of obtaining a patent for your valve when you should be able?

Ans. I did not. I tried several different parties at different times, when I thought I could get them to help me.

Int. 37. Did M'r Poore assist you in introducing your valve, and has he remained connected with you in your business up to the present time?

114 Ans. He did, and he has. He has rendered all the assistance I required.

Cross-examination by James B. Robb, esq., of counsel for complainant:

Cross-int. 1. Had you, before you applied to M'r Poor for assistance, made any other payment on your house than the sum mentioned by you in your direct examination?

Ans. I had not.

Cross-int. 2. Were you still in possession of that house as owner?

Ans. I don't understand you as to what house you mean now. Where was the house?

Cross-int. 3. What house did you mean in your direct examination, in which you say you had paid about one hundred and fifty dollars?

Ans. I meant a small house which I built in Poultney, and paid on the same, I think, about one hundred and fifty or two hundred dollars—built by Bosworth and Colvin, and mortgaged to them or one Beaman. Now will you read that previous question. (Cross-interrogatory 2 reread.) I was not.

Cross-int. 4. Had you sold it?

Ans. I had, subject to the mortgage to Hiram Warren.

Cross-int. 5. How long before you talked with M'r Poor the first time about the valve?

Ans. I think it was in 1856 I sold it. It might have been in 1857.

Cross-int. 6. How much did you sell it for?

Ans. I cannot state the exact sum; I think about seven hundred dollars, seven hundred or fifty—seven hundred, I think.

Cross-int. 7. Did you own any other house or real estate beside that before you talked with M'r Poor about the valve?

Ans. I did. I owned a small house in Troy, N. Y., which I bought for

ten hundred and fifty dollars, subject to a mortgage of about seven hundred dollars.

Cross-int. 8. When did you buy that?

Ans. I think it was in February, 1862.

115 Cross-int. 9. How much did you pay on that house?

Ans. I think it was three hundred and fifty dollars.

Cross-int. 10. From whom did you buy that?

Ans. Of William F. Matthews, who, I think, works at the Old Colony Railroad shop, in South Boston.

Cross-int. 11. Have you named all your operations in real estate between 1851 and the time you had your first conversation with M'r Poor?

Ans. I have, if you mean buying and selling.

Cross-int. 12. Did George Ross ever make a pattern for a valve for you?

Ans. He did.

Cross-int. 13. Was that the pattern of the first valve, or among the first valves you put into actual use?

Ans. I think not.

Cross-int. 14. Who made the pattern of a working valve for you before that?

Ans. I think I made one myself.

Cross-int. 15. Do you know a man named William Kemp?

Ans. I do.

Cross-int. 16. Did he not cast or make the castings of the first valve, or among the first valves that were put into actual use?

Ans. He did, for the Troy and Boston Railroad.

Cross-int. 17. Do you know a man named Frank Hemmingway?

Ans. I do.

Cross-int. 18. Did he not work on the first valve that was made for actual use?

Ans. I think he did.

Cross-int. 19. Were not Hemmingway and Ross at that time employed by the Troy and Boston Railroad Company?

Ans. I think they were.

Cross-int. 20. The first valve was put on the engine Wallingford, was it not?

Ans. It was.

Cross-int. 21. Was not that valve similar to the valve marked "Exhibit H[1]"?

116 Ans. It was, as I have stated in a previous answer, the answer to interrogatory 28, in regard to old Hinkley engines, where a copper pipe was used to turn the steam upward.

Cross-int. 22. Are you willing to testify positively that when the valve was tried the first time on the Wallingford there was anything used to turn the steam upward?

Ans. I am.

Cross-int. 23. Are you willing to testify that in trying the valve the first time the steam was turned upward?

Ans. I am.

Cross-int. 24. How was the copper pipe attached or connected with that valve? Explain by referring to Exhibit H[1]?

Ans. I don't think I could explain it by Exhibit H[1] so that you would understand it or the court. I can obtain an exhibit which will show you precisely how it was attached.

Cross-int. 25. Please do so, and explain now as well as you can how the steam was turned upward by that pipe.

Ans. On the engine Wallingford was attached a safety-valve on the top of a pipe about eight or ten inches high. On the top of the pipe was a flange about seven or eight inches in diameter. On the edge of the flange was a wrought iron band projecting upwards about an inch and a half, which had four bolt-holes in it tapped out. The copper pipe was screwed on to said flange by a bolt. The pipe was about two feet and a half long above the valve or flange.

Cross-int. 26. Are you willing to testify positively that the first valve tried on the Wallingford closed at the same pressure of steam at which it lifted?

Ans. It did not close at the same pressure of steam at which it lifted. I never have made a valve to close at the same pressure of steam at which it lifted. My claim is to reduce the pressure from the point at which it lifted.

Cross-int. 27. That valve closed at several pounds below the lifting-pressure, did it not?

Ans. It did. I made all the valves with that kind of a scale known as the old scale or lever-valve close several pounds below, on account of the friction of the many parts.

117 Cross-int. 28. When did you first apply, and to what engine, a valve having the spring like Exhibit H[1]?

Ans. I think in October or November, 1866, to engine Walloomsac, on the Troy and Boston Railroad.

Cross-int. 29. Did that valve differ in any respect from Exhibit H[1]? If yes, how?

Ans. That valve was like the valve in my circular cut, Exhibit M.

Cross-int. 30. Are you willing to testify positively that that valve closed before the steam ran down several pounds below the lifting-pressure?

Ans. I think it did run down several pounds below the first time I tried it. The boiler was new and foamy. It was my first trial of my valve with the spring directly over it as in the cut. I do not know but I did put one on the stationary boiler before, but think not. It was my first trial on a locomotive in that manner with the spring directly over it.

Cross-int. 31. Didn't you make some alteration in the valve first tried on the Walloomsac after it had been used a short time?

Ans. I do not recollect of ever altering the valve?

Cross-int. 32. Is it not a fact that, in the operation of that valve while it was on that engine, it always, or generally, closed at several pounds below the lifting-pressure?

Ans. What do you mean by several pounds?

Cross-int. 33. Is it not a fact that while that valve was in operation on that engine the pressure at which it closed was always, or generally, several pounds lower than the pressure at which it lifted?

Ans. I ran the engine Walloomsac the first trip after the valves were applied; think the right-hand valve blew off at one hundred and twenty and closed promptly at one hundred and seventeen pounds per square-inch pressure. The left-hand valve was set two pounds higher and closed at the same point, one hundred and seventeen. The right-hand valve, however, would take away all the steam the boiler would make, unless it was held down.

Cross-int. 34. Please hear the question read again and state whether you can make any further answer to the interrogatory.

Ans. It was, to my recollection, as my previous answer states.

118 Cross-int. 35. In your previous answer you were speaking, as I

understood you, of the first trip. The interrogatory covers the whole period of time in which that valve was used on that engine. Can you answer the question further than you have answered it in relation to the first trip?

Ans. I cannot change my previous answer, with the exception that the steam-gauge which was put on with a straight pipe and no siphon did vary fifteen or twenty pounds at different times by the heat or expansion, by getting hot. The engine was run for a year or two, I think, with the gauge in that shape, and the valves were not altered until the engineer requested that he might carry less steam, when the nuts were unscrewed, and the right-hand valve blew off at one hundred and ten, I think. I do not recollect more about it.

Cross-int. 36. In your previous answer, which you say you cannot change, you spoke of the operation of the valve during the first trip; you were asked whether it was not the fact that the valve, during the time it was on that engine, did not always, or generally, close at a pressure several pounds below the lifting-pressure. Can you answer further than your experience on the first trip enables you to speak of its operation during that trip?

Ans. I ran the engine several trips thereafter at different times and was on the engine with the engineer at other times. I never knew the safety-valve to act any different than at first. I don't recollect of their acting any different; never heard any complaint of them.

Cross-int. 37. Were the valves used on the Walloomsac made in every respect like the valve described in your patent?

Ans. They were, as I understand it, or if I understand the question.

Cross-int. 38. Will you describe particularly the construction of the valve used on that engine, and state whether it differed at all from Exhibit H[1]?

Ans. I think the valve was as stated in answer to cross interrogatory 29. That answer says the valve was like the valve in my circular cut, Exhibit M.

119 Cross-int. 39. How did it differ, if at all, from Exhibit H[1]?

Ans. I think it was like the one in the cut, Exhibit M.

Cross-int. 40. Did it differ from Exhibit H[1]?

Ans. Not as far as the valve was concerned.

Cross-int. 41. Does Exhibit H[1] correctly represent or embody your invention as you understand it?

Ans. It does, but not as it is now; just like anything I have ever used.

Cross-int. 42. Do you know who made Exhibit H[1]?

Ans. I think it was made by M'r Hemmingway, for experiment.

Cross-int. 43. How does it differ from the invention for which you applied for letters patent?

Ans. I think it is virtually the same, but it could never be used as in Exhibit H[1] on a locomotive, for the reason that the steam would blow down in front of the engineer, and of course he could not see ahead to run his train properly.

Cross-int. 44. Is not the valve in exact conformity with the description and drawings of your patent, Exhibit F?

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Ans. The valve is in exact conformity with the description in the patent, as shown in fig. 4, but the seat or bush of the valve is raised a little higher, that is, the shoulder on the bush E is a little longer than

is marked or shown in fig. 3, but it is the same as is intended in my description on page 99 of the printed record in this case. I quote, "With my improved supply-valve, constructed as now described, and attached to the generator in the usual way, and the steam escaping in the direction indicated by the arrows in fig. 3." It will be noticed the outer arrows in fig. 3 are curved, showing a tendency for the steam to go upwards or be directed upwards. The valve, Exhibit H[1], in experiments tried at East Cambridge, worked just as well as far as opening and closing are concerned, as any safety-valves which I make; but the steam came down around it so as to drive us away from the boiler. It would, in my opinion, work just as well were the shoulder of the valve-seat of any length longer than in Exhibit H[1], as sixteen feet, for instance. I mean by shoulder, the distance from the cast iron to the top of the bush, or under-edge of overhanging lip.

120 Cross-int. 45. State what the invention is, "intended" in the part of the patent quoted in the preceding answer from page 99, and also state the mode of operation and the principle employed, without reading the patent, if you can do so.

Ans. The safety-valve referred to is the whole safety-valve; that is, the combination of the valve and seal. Can I refer to the drawings to explain further?

Cross-int. 46. Can't you answer that question without referring to the drawings?

Ans. I think I would have to refer to some drawing or exhibit to make you clearly understand it.

Cross-int. 47. The answer called for is intended to show to the court the invention referred to, its mode of operation, and the principle employed; can you not make it intelligible to the court by a verbal statement, without referring to the drawings or an exhibit? If not, why?

Ans. Because I do not think it can be perfectly or fully explained in all its points or actions, especially to persons who are not mechanics, without some exhibit.

Cross-int. 48. Answer the question, if you please, by a verbal statement, without referring to the drawings or an exhibit, as well as you can.

Ans. The invention intended in the part of the patent quoted, is a safety-valve with an enlarged head, that is, a head beyond the ground-joint, which, in connection with the valve-seat, so terminates as to make a stricture and an annular chamber for the purpose of overcoming the resistance of the increased tension of the spring as the valve raises from its seat, as in blowing off, thereby causing the valve to raise still higher from its seat than it would otherwise do were not the head of the valve enlarged beyond the ground-joint and terminated as stated. The mode of operation is, that as the valve lifts and the steam issues from the ground-joint, it strikes against and expands in the walls of the annular chamber or space formed by the enlarged head and combination of an outer portion of the seat where the head of the valve and the edge of the seat nearly touch one another. This is what I call the

121 stricture. The direct current of the steam being broken has to reunite to pass the stricture, thus making a pressure in the annular space or chamber, which causes the valve to lift higher than it would otherwise do; and it lifts just as high as it can until the pressure in the annular space is in proportion to the increased tension of the spring minus the friction of the parts of the machine. In other words, the valve would rise higher were it not for the friction. The principle

upon which the valve operates or rises is due to the expansion of the steam in the boiler and between the ground-joint and stricture.

Cross int. 49. Please explain what you mean by the word stricture, in the preceding answer, and why you call that portion of the valve a stricture.

Ans. What I mean by stricture is the space between that portion of the valve and the edge of the seat where the steam issues into the open air in leaving the annular space or chamber. I call it a stricture because it obstructs the free passage of the steam between the annular space and the open air.

Cross-int. 50. What proportion must the size of that space bear to the size of the space from which the steam issues at the ground-joint of the valve to make it a stricture?

Ans. Any proportion which will cause a pressure in the annular chamber.

Cross-int. 51. What proportion is that?

Ans. As the space from which the steam issues at the ground-joint is variable, and the stricture in my valve is also variable, I do not know why the previous answer is not intelligible or correct.

Cross-int. 52. Does the previous answer give the relative proportion between the size of those two spaces?

Ans. The size of the space at the ground-joint is nothing while the valve is not blowing; therefore there can be no proportion.

Cross-int. 53. Is there any stricture, as you use the word stricture, between the edge of the lip of the valve and the valve-seat when the valve is not blowing?

Ans. There is not.

Cross-int. 54. Now, please state what proportion the size of that space, when the valve is blowing, must bear to the size of the
122 space from which the steam issues at the ground-joint of the valve to make it a stricture.

Ans. I think my answer to the 50th cross-interrogatory is sufficiently intelligible.

Cross-int. 55. Please answer the question without reference to your answer to the 50th cross-interrogatory.

Ans. I do not know how to limit the proportions without the rise and sizes of the different parts or combinations of parts are limited.

Cros-int. 56. What is the size of the valve marked "Plaintiff's Exhibit A, C. W. T., Examiner, George W. Richardson v. Edward H. Ashcroft?" What sized valve is that called?

Ans. Two and a quarter inches.

Cross-int. 57. Please answer the 54th cross-interrogatory in reference to one of your two-and-a-quarter-inch valves, assuming it to rise one-twelfth of an inch.

Ans. Were the space between the head of the valve and the edge of the seat one-twelfth of an inch previous to the valve rising, I think it would cease to be a stricture for any appreciable benefit with the springs proportioned as I use for the same on locomotives.

Cross-int. 58. Please give the area in square inches and decimal parts, or in decimal parts of the space at the ground-joint where the steam issues of a two-and-a-quarter-inch valve when the valve is raised one-twelfth of an inch; also, the area of the stricture, so called.

Ans. I will have to get a book of tables and instruments to make these measures. I have been used to doing that way. Having no tools at my command to make the measurements I will have to retire and obtain them.

Cross-int. 59. Which space would be the greater?

Ans. The outer.

Cross-int. 60. In a valve constructed according to the description in your patent, how much greater proportionally would the outer space be than the inner space when the valve is raised one-twelfth of an inch, the spring being adjusted to a pressure of one hundred pounds to the square inch?

123 Ans. I do not see that the adjustment of the spring would make any difference in the size of the opening, the opening being already given, one-twelfth of an inch.

Cross-int. 61. Please answer the question, then, assuming that it would make no difference as to the adjustment of the spring.

Ans. I do not see as I can answer the question intelligibly without measuring the lift and opening of the valve, not being able to calculate the openings on the angles without tools to do it with.

Cross int. 62. What tools do you need for that purpose?

Ans. Some drafting instruments, to make a draft of the valve raised one-twelfth of an inch above its seat, as I am unable to make the measurements accurately otherwise.

Cross-int. 63. Haven't you before you a draft of the valve in the drawings of the patent?

Ans. I have, but not with the valve in the position mentioned in the question.

Cross-int. 64. What sized valve is shown in the drawing?

Ans. Two inches and one-quarter.

Cross-int. 65. Suppose the stricture, as you call it, to be one sixty-fourth of an inch, how much greater proportionally would that opening be if the valve was raised one-twelfth of an inch; more than double, would it not?

Ans. I should think it would. Not being able to measure it, I give that as my opinion.

Cross-int. 66. How did you determine the size of the valve as stated in answer to cross-interrogatory 64? Did you not apply a measuring instrument to it?

Ans. I did.

Cross-int. 67. What is the diameter of the opening of that valve shown in the drawings?

Ans. What particular part do you mean by the opening?

Cross-int. 68. I mean that part through which the steam passes from the boiler to the ground-joint.

Ans. Two inches and one-quarter.

Cross-int. 69. Now, cannot you state or give the area of the space through which the steam passes, supposing the valve to be

124 raised one-twelfth of an inch, without reference to any book of tables?

Ans. Having always used the tables for that purpose since my boyhood, I have forgotten the rules to figure such things accurately.

Cross-int. 70. What is the diameter of that part of the valve shown in the drawings between the upper arrows in fig. 32?

Ans. Three inches and seventeen sixty-fourths, as near as I am able to measure with U. S. standard rule.

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Cross-int. 71. Are you now able to answer cross-interrogatory 58?

Ans. I cannot answer that question any better than I did before, having no more means of ascertaining than then. As near as I can

approximate, about one-half of a square inch for the space at the ground-joint where the steam issues. The area of the stricture, so called, is about ten-sixteenths of a square inch, as near as I can approximate it. This answer is made with reference to Exhibit F.

Cross-int. 72. What allowance did you make for the difference between the diameters of the two rings of the spaces?

Ans. The difference in their diameters, as near as I could approximate mentally. I meant circumferences when I said diameters. The circumference of one is eight and of the other ten inches. This has reference to my other answer, as near as I can approximate it mentally.

Cross-int. 73. Please answer the 58th cross-interrogatory, with reference to Exhibit L, as near as you can by approximation.

Ans. The area of the ground-joint would be the same as in previous answer, one-half of a square inch. The area of the stricture would be about ten-twelfths of a square inch.

Cross-int. 74. Do you make any allowance for the space at the part called the stricture before the valve rises—that is, when the valve is down on its seat? If so, what allowance do you make for that?

Ans. I did make an allowance mentally, and told you as near as I could.

125 Cross-int. 75. What is the area approximately of the opening at the stricture, so called, in a valve constructed like Exhibit L, when the valve is seated?

Ans. About ten thirty-seconds of an inch.

Cross-int. 76. Is it not necessary to the successful operation of the valve that the opening of the stricture should be varied with the variations in the adjustment of the spring to different pressures?

Ans. I say in my patent, Exhibit F, on page 99 of the printed record in this case, "for a strong spring or balance, this space should be diminished, and for a weak spring or balance it should be increased to regulate the escape of the steam as required." And for a high pressure I use a strong spring, and for a low pressure a weaker one; but to suit different parties as to the amount of steam to be blown off with the same adjustment I change the opening of stricture.

Cross-int. 77. Please explain why you said in answer to cross interrogatory 60 that you did not see that the adjustment of the spring would make any difference in the size of that opening.

Ans. I can't see but what the proportions were given or understood in the question and the rise of valve given; therefore the spring could have nothing to do with the question, as I understand it.

Cross-int. 78. In a valve constructed according to the description in your patent, with a spring adjusted for the valve to blow off at a pressure of one hundred pounds to the inch, what should be the size of the opening at the part called the stricture to operate successfully?

Ans. There could be no accurate size given. It would depend upon the size of the valve and upon the size of the boiler to be relieved, and upon the strength or elasticity of the spring. In a valve of the size of Exhibit L, with the spring of the size and length in Exhibit G, the stricture would have to be about the size as in Exhibit L to relieve the pressure in an ordinary locomotive boiler.

Cross-int. 79. What do you mean by the words in your patent, quoted, in answer to cross-interrogatory 76, "a strong spring" and "a weak spring"? Please state what you consider a strong spring and what a weak spring as there stated.

Ans. Were the spring in Exhibit G nine-sixteenths instead of
126 three-eighths square, it would of course be stronger. Were the

spring one-quarter inch square it would be weaker. Therefore, for the one-quarter-inch spring, the opening would have to be larger and for the larger spring smaller than it now is in Exhibit L.

Cross-int. 80. Please answer the question by a verbal statement without reference to any exhibit, if it admits of an answer in that form.

Ans. The words in the patent convey their own meaning or definition to those skilled in the art.

Cross-int. 81. Is that the only answer you are willing to give to that question?

Ans. I think it is sufficiently intelligible.

Cross-int. 82. Please answer the preceding interrogatory.

Ans. There are so many sizes of valves and springs, and so many pressures required, that my answer to cross-interrogatory 79, giving three sizes of springs and one size of valve with one hundred pounds to the square inch, the larger and smaller would, I think, be strong and weak.

Cross-int. 83. Is the spring in Exhibit H[1] a strong spring or a weak spring in the sense in which you use those words in your patent?

Ans. In the sense in which I understand it, having used scales and levers, it would be a little weaker than the old locomotive scale.

Cross-int. 84. To what degrees of pressure is that spring capable of being adjusted? State the highest and lowest.

Ans. I should think from about 80 to 140 pounds to a square inch.

Cross-int. 85. When adjusted to a pressure of 140 pounds to the square inch, is it then a strong spring in the sense in which you use the word strong in the patent?

Ans. It would be weaker at 140 than at 80 and vice versa, but to make the valve blow just right to suit me I should reduce the stricture for 80 and increase it to 140, or should use a little heavier spring at 140 or lighter one at 80.

(Question reread at request of witness.)

No, the spring would be a weak spring, that is weaker than I had
127 intended to convey, it being directly over the valve, while those I had in my mind in the patent were under leverage of ten or eleven to one; consequently the small spring with the leverage would become a strong spring.

Cross-int. 86. What did you say about the judgment of every workman as to the amount of work a spring can do? Please repeat the words you used upon that subject, and which you did not make a part of the previous answer.

Ans. I said there was a judgment in every skilled mechanic to tell a strong spring or a weak one, or about what work a spring would do.

Cross-int. 87. And a skilled mechanic would vary the opening of that part of the valve you call the stricture accordingly in working under the directions of the specification, would he not?

Ans. Vary the opening from what and to what, and for what purpose? I don't understand the purpose you intend.

Cross-int. 88. Please hear the question read again, and state whether you cannot answer it without being informed of the purpose of the inquiry.

Ans. For an ordinary spring or balance, as was used on locomotives at that time, and there were very few springs or balances used in other places, a spring with a leverage of ten to one, and some builders made more or less leverage with the same balances, I should alter the opening or stricture in the valve to suit the balances usually.

Cross-int. 89. Suppose a valve, constructed like and of the size of Ex-

hibit L, raised or lifted while blowing off one quarter of an inch, what would be the area of the opening in that case at the part called the stricture? State as near as you can, approximately if not definitely.

Ans. About three times the area given in a previous answer, or two and one-half square inches; but I have never seen my valve raised as high as that, not of that size.

Cross-int. 90. What was your business in 1852, and for whom did you work?

Ans. Machinist; for M'r Ruggles.

Cross-int. 91. What was the nature of the work on which you were employed by M'r Ruggles as a machinist?

128 Ans. Custom-work.

Cross-int. 92. Of what description?

Ans. Job-work of all kinds that came into the shop. I couldn't describe it more fully.

Cross-int. 93. State generally.

Ans. All kinds of machinery, engines or other machinery, mill, railroad-work.

Cross int. 94. What kind of railroad-work, and what kind of engines?

Ans. We did railroad castings and switches, draws, and stationary engines, and repairs.

Cross-int. 95. How long did you work for M'r Ruggles?

Ans. I think about two years and a half at that time.

Cross-int. 96. For whom did you work next, and where?

Ans. For John H. Bowman & Co., at Rutland, Vermont. The Brandon Iron Company had an interest; whether it was called their works or not I don't remember. My charges were to John H. Bowman & Co.

Cross-int. 97. State generally the nature of the business carried on by them, and the nature of the work you did.

Ans. It was about the same or the same as the other shops. I had charge of their machine-shop, as foreman, for a while, a short time.

Cross int. 98. How long did you work for them, and what wages did you receive?

Ans. About seven or eight months, at two dollars per day, I believe.

Cross-int. 99. Was that your pay while foreman in their shop?

Ans. It was.

Cross-int. 100. For whom and where did you work next, and how long did you continue in that employment?

Ans. For M'r Ruggles, in Poultney, Vt. I cannot recollect exactly how long; about eight or nine months, I think.

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Cross-int. 101. In what year was that?

Ans. I think in 1854. I am not positive, but think that is right.

129 Cross-int. 102. When and for whom did you work next?

Ans. I think it was for the lessees of the Rutland and Washington Railroad, Thomas H. Canfield and others, at Salem, New York.

Cross-int. 103. How long did you continue in their employ?

Ans. Until the railroad was put into the hands of the receiver. I cannot tell the precise date, but I think until March, 1855.

Cross-int. 104. What was the nature of your work in that employment?

Ans. All kinds of machinist-work in the repairs of engines.

Cross-int. 105. What were your wages during that time?

Ans. I think one dollar and seventy-five cents per day.

Cross-int. 106. For whom and where did you work next, and in what employment or business?

Ans. I worked a very short time for M'r Gray, in East Poultney, then for M'r Ruggles, in Poultney. I worked with M'r Ruggles until the fall of 1855, when I had my right eye put out. When I was able to go to work again M'r Ruggles refused to let me work in the shop, even at reduced wages. Then I went to Rutland and worked through the winter for Bowman & Mansfield, my household goods being stored in Salem. I then went to work when the road started, I should think in March or April, 1856, at the Rutland and Washington Railroad repair-shop, in Salem, in the same shop referred to in a previous answer.

Cross-int. 107. How long did you work there?

Ans. I worked there until April, 1858—about that time.

Cross-int. 108. Where next did you work?

Ans. In the Troy and Boston Railroad repair-shop, at Troy, N. Y.

Cross-int. 109. What was the nature of your employment there, and how long did you continue in that employ?

Ans. I went there as foreman of the repairs under M'r Church, master-mechanic; continued to work in the shop as machinist and foreman until 1861 or 1862, when my health was so poor my family physician advised me to go into the open air, when I got permission to run
130 extra trains as locomotive engineer. My health being improved, I continued to work as an engineer and in the shop until February, 1867, I believe.

Cross-int. 110. What wages did you receive while in the employment of that company?

Ans. Different wages at different times. I went to work for two dollars per day; was cut to one dollar and seventy-five cents at one time; can't state the time; my wages were raised to two dollars again; think I had two dollars per day from that to 1860, and sixty dollars per month from that time until wages were raised during the war, when I worked for engineers' wages. I do not recollect the precise wages. In the spring of 1865 I took charge of a wood-train as engineer and conductor at a slight increase of wages over engineers' wages. Engineers' wages were something like eighty dollars a month at that time. In August, I think, in 1865, the machine-shop of the Troy and Boston Railroad, in Troy, burned. The foreman was injured at that time, when I was called into the shop to take his place. When he was well I continued in the shop and on the road until the time stated in a previous answer.

Cross-int. 111. On what wages?

Ans. I think eighty-three dollars and thirty-three cents per month, some of the time. I cannot state that it was so all the time.

Cross-int. 112. Was it more or less than that?

Ans. It might have been less some months and more others, and think it was.

Cross-int. 113. You have stated in a previous answer, if I understand you correctly, that the opening at that part of your valve between the overhanging lip and the edge of the bushing is called a stricture, because it obstructs the free passage of the steam. Is that the reason why that opening is called a stricture?

Ans. I call it a stricture because that word conveys the best meaning of its use as I understand it, not being accustomed in the use of language very much; it conveys, I think, the proper office which that opening performs.

Cross-int. 114. What meaning do you intend to convey by the use of that word stricture?

Ans. Suppose the valve to contain four square inches of area
131 within the ground joint, with the spring screwed down four-twelfths of an inch to hold the boiler-pressure of one hundred pounds per square inch, the upward force or pressure on the spring is four hundred pounds. Suppose the whole area of valve within the lips *c c*, Exhibit F, to be eight square inches, while the valve is blowing with a lift of one-twelfth of an inch, the pressure or force to raise the spring must be about five hundred pounds, or one hundred pounds additional. The office performed by the stricture makes this additional force or pressure.

Cross-int. 115. What is that office performed by the stricture?

Ans. The office performed by the stricture is to reunite or close the current of the issuing steam after it has expanded or been broken up, as I used the term in a previous answer, the 22d direct, in the annular space or chamber, as in D on Fig. 3 in Exhibit F. In closing up the passage and obstructing the free escape of the steam into the open air, it forms a pressure within the annular space or chamber which causes the valve to rise until the pressure or force is equal to the tension of the spring when so raised, which I think is fully illustrated in my previous answer.

Cross-int. 116. The free escape of the steam, then, may be obstructed in the sense meant by you, by an opening at the place called the stricture larger than the opening of the passage of the steam into the annular chamber; isn't that so? Or, in other words, the steam will expand within the annular chamber, and exert a lifting force upon the valve, although the area of the opening from the annular chamber may be larger than the area of the opening into the annular chamber, will it not?

Ans. It is so, as I have explained in a previous answer in regard to the difference in the area at the ground joint and at the stricture, so called. It does exert a lifting force of about one hundred pounds additional, as I have explained in answer to cross-interrogatory 114.

Cross-int. 117. And if the valve should lift more than one-twelfth of an inch the steam in the chamber would continue to exert that lifting force, notwithstanding the area of the opening would be also increased, would it not?

Ans. All other conditions being the same, it would.

132 Cross-int. 118. What change would you make in Exhibit G to cause a portion of the steam issuing from the ground joint to escape upwards through the space surrounding the curved lip of the valve?

Ans. I do not see how such change could be made without the construction of a new valve.

Cross-int. 119. Couldn't that effect be produced by contracting the opening at the part to which the tin pipe is connected?

Ans. I presume it might, were that part sufficiently small, when a part of the steam would issue from the opening in the tin pipe and a part around the edge of the valve.

Cross-int. 120. That is, by contracting the opening at the tin pipe you would produce an obstruction to the escape of the steam at that point, causing a portion of it to pass out at the top, would you not?

Ans. I said I thought it would do so were the opening at the tin pipe sufficiently contracted.

Cross-int. 121. In your opinion how much should it be contracted to produce that effect?

Ans. I think it would have to be nearly closed, perhaps to an inch in diameter. I cannot tell more nearly, not having tried anything of that kind.

Cross-int. 122. If you were directed to construct a valve like Exhibit G, except that you were told that a portion of the steam must escape or pass off through an orifice at that part to which the tin pipe is attached, and the other portion should pass off or escape at the opening around the projecting lip, you would make the lower opening or orifice about one inch in diameter, would you not?

Ans. It would have to be the result of experiment with me. I cannot state nearer than I did in answer to the previous question.

Cross-int. 123. What would be the area of the opening around the projecting lip if it were one thirty-second of an inch wide? State as near as you can, approximately.

Ans. About one-half of one square inch.

Cross-int. 124. How do you make that?

Ans. As near as I can approximate.

Cross-int. 125. State how you arrive at that result.

133 Ans. Taking the circumference of the rim as about sixteen inches. The exhibit being taken apart so that I can measure it, I find the diameter to be four and one-eighth inches, and the circumference would be about thirteen inches, which would make thirteen thirty-seconds of one square inch.

Cross-int. 126. What would be the area of an opening or orifice of one inch diameter?

Ans. The tables in books will give it. I have no means of informing you at present, positively. Approximately, seven-eighths of one square inch.

Cross-int. 127. How did you understand M'r Ashcroft constructed the safety-valve referred to in the letter of George W. Richardson & Co., dated May 12, 1868, a copy of which you have produced and marked "Exhibit P"?

Ans. Precisely like mine.

Cross-int. 128. Did you not understand that he had letters patent of the United States for the valve he was then making?

Ans. I did not, as I understood he was making it, as near as I can recollect now.

Cross-int. 129. What did you understand his patent was for? What kind of valve?

Ans. The letter, Exhibit O, gave me to understand that it was an infringement on my patent of September 25, 1866.

Cross-int. 130. Then you understood that if his valve contained means for getting an increased surface for the action of the steam as it escaped from the boiler, it infringed your patent, did you?

Ans. I understood, as I said before, that he was making valves precisely like mine.

Cross-int. 131. Please answer the question after hearing it read again.

Ans. I did so understand it.

Cross-int. 132. Please quote from the letter written by M'r Ashcroft to you, marked "Exhibit O," dated April 28, 1868, that part of it which gave you to understand that he was infringing your patent.

Ans. That part of the letter in which he states, "The nature
134 of the invention is in getting an increased surface for the action of the steam after it has passed the maximum point"; and also by some information, which I cannot now recollect just how I got it, that he was making safety-valves precisely like mine.

Cross-int. 133. Why did you not allude to that information when your firm answered that letter, Exhibit O, on the 12th of May, 1868?

Ans. I did not do, or do not do, the writing myself; could not state positively that I have seen the answer until now.

Cross-int. 134. Did you not intend, by your letter of the 12th of May, 1868, to have M'r Ashcroft understand that you claimed that any safety-valve which contained an increased surface or curved lip or extension, against which the escaping steam impinged, was an infringement of your patent?

Ans. I cannot say that I did. I had never seen M'r Ashcroft's patent. I do not know that I have ever seen it. I did not write the answer; do not know that I have ever seen it, as I said before. I mean the patent alluded to, as I understand it. I don't know as I understand the patent alluded to. I should like to see the patent alluded to.

Cross-int. 135. Does Exhibit 4, J. G. S., Examiner, now shown you, being a certified duplicate of the model of your valve deposited in the Patent Office, correctly represent your invention as you understand it now?

Ans. I think it correctly represents the model I deposited in the Patent Office. I understand my invention now as described, specified, and claimed in the patent.

Cross-int. 136. Can you answer the preceding cross-interrogatory by saying either yes or no?

Ans. Not with your question as I now understand it. I understand the patent to grant me all the invention contained therein.

Cross-int. 137. Please say whether that exhibit correctly represents your invention as you now understand it.

Ans. I do not understand it any different than I have before stated.

Cross-int. 138. Please hear the question read again and be kind enough to answer it.

135 Ans. What do you mean by "as you now understand it"?

Cross-int. 139. Please answer the question, if you can or are willing to do so, without evasion.

Ans. I do not wish to evade the question, and wish to give you as intelligent an answer as I can, as I understand the question. You ask me, as I now understand it—I would like to know just what you mean.

Cross-int. 140. Does that exhibit correctly represent your invention as you now understand that invention?

Ans. It does, together with the patent granted to me.

Cross-int. 141. Does that model correctly represent your invention? If not, in what does it differ from that invention as you now understand it?

Ans. I think the patent explains the differences and modes of application.

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Cross-int. 142. Please state, without reference to the patent, whether that model correctly represents your invention?

Ans. It does represent the essential features or principles of my invention.

Cross-int. 143. Does it differ in any respect, and, if yes, in what, from your invention?

Ans. My invention, as described in my patent, explains the modifications or changes to be made in its use to make it act or work as desired.

Cross-int. 144. Please answer the question without reference to your patent.

Ans. In my invention the bush or part with the hole through it, through which the ribbon passes, may be larger or smaller, and the valve-head on the edge of which the name is marked may be larger or smaller, making the opening between the downward projecting lip of said head and the top and outer edge of the bush larger or smaller. The distance between the ground joint and the edge of the valve-seat may be larger or smaller, and many other modifications and proportions may be made.

Cross-int. 145. Is that a correct model of your invention?

136 Ans. I think it is, with the conditions of the previous answer.

Cross-int. 146. Is it a correct model of your invention without the conditions of the previous answer?

Ans. It is not. A correct model of my invention could not be made without conditions.

Cross-int. 147. Why not?

Ans. For the reasons stated, of the many conditions in which it is used.

Cross-int. 148. What are those conditions?

Ans. High and low pressure, large and small boilers, heavy and light springs, the use of springs with or without levers, consequently large and small strictures to make the valve raise and blow off as desired.

Cross-int. 149. What modification is it necessary to make for high and what for low pressure?

Ans. I cannot state exactly the modification, or whether the proportions of this particular exhibit are just right for one hundred and fifty pounds per square inch, and also for twenty-five pounds per square inch, but I think were the upper and outer edge of the bush slightly reduced or turned off, making the stricture or opening a little larger, it would work well with the spring proportioned properly to the valve and pressure. I cannot state more accurately from memory and sight, not having tried the experiments with that particular size.

Cross-int. 150. What size valve, constructed according to your invention, is it necessary to use with the steam at low pressure?

Ans. Not any particular size. A very small valve, I think, is more difficult to make, and have it work nicely and accurately, than a large one.

Cross-int. 151. What do you consider a large one?

Ans. A two inch and a quarter one is large enough to illustrate the idea.

Cross-int. 152. What would be the size of the opening at the stricture of a two and a quarter inch valve for a pressure of twenty-five pounds?

Ans. It would have to be of different sizes for different springs.

137 Cross-int. 153. State the variations of size for the different springs, and describe those different springs.

Ans. I should think with a valve two and a quarter inches in diameter, which has about four square inches area within the ground joint and eight square inches within the projecting lips of the valve, and a spring of five-sixteenths square steel, well tempered, the inside diameter and length of spring in Exhibit G, the stricture or opening at the outer edge would have to be about one-thirty-second of an inch. I think such a valve would work very well.

Cross-int. 154. Answer cross-interrogatory 152 for a pressure of one hundred and fifty pounds.

Ans. I think the valve would work very well with a spring seven-sixteenths square, just as in preceding answer.

Cross-int. 155. What variations should be made in that opening to

work properly under pressure of one hundred and fifty pounds to meet different variations in the size of the spring used?

Ans. If the spring was three-eighths square, with other conditions as in the last answer, the opening or stricture, I think, would have to be slightly larger.

Cross-int. 156. How much larger?

Ans. Perhaps one one-hundredth of an inch.

Cross-int. 157. With the springs generally used and the pressure one hundred and twenty pounds, what should that opening be?

Ans. I cannot state accurately; about one thirty-second of an inch for that sized valve.

Cross-int. 158. What should it be for a three-inch valve under those circumstances?

Ans. I do not think the spring would be quite strong enough for a three-inch valve of one hundred and twenty pounds to operate correctly.

Cross-int. 159. What should that opening be for a three-inch valve at a pressure of one hundred and twenty pounds with a spring strong enough?

Ans. With a three-inch valve, half-inch square spring, and valve proportioned as the other, the opening would have to be very nearly the same, perhaps a little larger.

138 Cross-int. 160. What would be the opening of a three-inch valve with a suitable spring, the pressure being one hundred pounds?

Ans. With a seven-sixteenth spring, I think the last-named opening would be about right.

Cross-int. 161. What would it be for a pressure of twenty-five pounds?

Ans. I think about one thirty-second of an inch with a spring suitable. I have never, I think, tried a valve with as low pressure as that; with a spring suitable I think that might do; it might have to be varied more or less.

Cross-int. 162. Does the size of the opening depend upon the size of the valve? If so, under what circumstances?

Ans. The size of the opening depends upon the proportions of the valve and the proportion of the spring to the valve.

Cross-int. 163. Please explain your last answer, and state whether the size of the opening is increased in proportion to the increased size of the valve; and, if so, what the proportional increase of that opening is.

Ans. I cannot state the exact proportion; have given, as near as I can judge, some proportions in my previous answers.

Cross-int. 164. If you were called upon to make a four and a half inch valve, according to the description of your invention stated in the patent, what size would you make the opening at the part called the stricture?

Ans. It would depend upon the size of the head of the valve or area of the valve within the projecting lips, in proportion to the size of the valve within the ground joint.

Cross-int. 165. Please answer that question.

Ans. I cannot answer that question correctly without calculating the proportions named in the preceding answer, never having made a valve of that size.

Cross-int. 166. Does your specification contain any directions for making a valve of that size?

Ans. It does not.

Cross-int. 167. Suppose you had before you a drawing made by
139 scale representing your valve, with a diameter of one inch, what would you make the size of that opening for a four and a half inch valve, made according to that drawing and the directions of your patent?

Ans. I cannot tell in calculating it mentally, but I can make a valve of that size. I can make a valve of that size, I have no doubt, and have it work well; but I have never made one.

DECEMBER 19, 1872.

Cross-int. 168. Can you answer cross-interrogatory 107 more definitely now?

Ans. About seven one-hundredths of an inch.

Cross-int. 169. How did you arrive at that?

Ans. Simply by calculation, having never made a valve of that size up to this time.

Cross-int 170. Please state the elements of the calculation.

Ans. My calculations in this case were to have the outer head of the valve to the stricture about twice the area of the valve within the ground joint, and the opening in proportion to the size of the valve would be in proportion to the size as the drawings in the Patent Office, previously alluded to, indicate.

Cross-int. 171. Have you a diagram representing the valve in different sizes, showing the relation of the area at the ground joint and at the stricture, so called, under different circumstances? If yea, will you produce it?

Ans. I have a diagram showing the openings at the stricture and variations of openings of stricture and ground joint at different lifts of the valve, which drawing was made to show the variation of openings at stricture and ground joint. I produce that diagram.

(Diagram produced is marked "Exhibit F, J. G. S., Examiner.")

Cross-int. 172. Are the openings shown in that diagram the same under the varying pressures, within certain limits? I mean, will the valve as there constructed work successfully under different pressures
of steam, or is it necessary to vary the opening to adapt
140 the valve to successful operation, according to the degree of pressure in the boiler to which it is to be applied?

Ans. It is necessary to change the openings slightly for different pressures, or to make a stronger or weaker spring, as in answer to a previous question, the number of which I do not recollect. I have in some cases had the outer edge of the valve screwed down or up to make this change; that is, adjustable.

Cross-int. 173. How do you determine the degree of variation necessary to adapt the valve to a particular pressure or boiler?

Ans. I test the valve, and make the opening larger or smaller, as the case requires. The opening has to be altered so slightly for different pressures that I cannot always make it work perfectly to suit me the first time. One one-thousandth part of an inch in the width of this opening makes a great difference in the opening and closing of the valve.

Cross-int. 174. In what way does it affect the opening and closing of the valve, and in what degree?

Ans. I have known valves that were blowing just right, or reducing the pressure from 126 lbs. to 118 lbs. by increasing the opening 1-1000 of an inch, to blow constantly until the steam increased two or three

pounds above 120 lbs. before they would lift sufficiently to take away the steam the boiler was making or reduce the pressure. With an opening of 1-1000 of an inch less than at first the valve would open promptly and certainly, and the steam be reduced to 114 lbs., which is lower than we wish to go generally.

Cross-int. 175. Is it not frequently the case that the pressure gains two or three pounds before the valve lifts sufficiently high to begin to lower the pressure?

Ans. I do not know of many valves acting that way, except a few that prefer to have them so, making them so on purpose. I do not intend to make them so myself, or leave them so in my manufacture.

Cross-int. 176. Do you consider a valve so made or so operating to embody your invention?

Ans. I do consider a valve so made to embody my invention. I did not invent the operation.

141 Cross-int. 177. Suppose the valve to be made originally with the opening of the exact dimension necessary to ensure its lifting sufficiently at 120 lbs., but by the using of it the opening became enlarged so that it would not rise sufficiently to begin to relieve pressure until it reached three or four pounds above 120, would you consider that that valve in that condition embodied your invention?

Ans. I would if the valve was like mine, as three or four pounds on 120 is not a large increase.

Cross-int. 178. Suppose the valve to be constructed like yours with the opening of the exact size necessary to ensure its lifting sufficiently at 80 lbs., and by the using of it the opening became enlarged so that it would not rise sufficiently to begin to relieve the pressure until it reached three or four pounds above that pressure, would you consider that the valve in that condition embodied your invention?

Ans. I would.

Cross-int. 179. Suppose the pressure mentioned in the preceding interrogatory to rise six pounds under the circumstances mentioned in the interrogatory, in your judgment would the valve then embody your invention?

Ans. I do not make, nor have I ever known valves to become so worn, and were they to become so or be in that condition they would be dangerous and worthless.

Cross-int. 180. Would a valve so constructed, that is "like" yours, but having the width of the opening of the size to admit the pressure to rise six pounds above the eighty pounds mentioned in cross-interrogatory 178, in your judgment, embody your invention?

Ans. I think it would as far as it relieved the boiler at that point, though I do not make any, nor could I sell any acting thus.

Cross-int. 181. Please explain what you mean by the words "as far as it relieved the boiler at that point."

Ans. As far as it makes a variable stricture.

Cross-int. 182. What do you mean by that? Please explain.

Ans. The area at the stricture in the different figures in Exhibit T shows the variation of the stricture at different lifts of the valve.

Cross-int. 183. Please hear the 180th cross-interrogatory read again, and carefully consider it, and answer it.

142 Ans. I think it would as far as it made a variable stricture to assist in raising the valve at that point.

Cross-int. 184. What do you mean by your last answer? Explain it, and state whether a valve so constructed that the width of the opening

would permit the pressure to rise six pounds above the eighty pounds mentioned in cross-interrogatory 178 would embody your invention.

Ans. When the pressure would rise six pounds, the steam escaping at the ground joint would be issuing with considerable more force and raise the valve suddenly and considerably higher than it would do were not the stricture there, when the valve would suddenly close. It sometimes happens that the foam on the water in the boiler gets between the wings and the bush of the valve, and causes it to act as above stated for once or twice, the valve acting perfectly well afterwards. So it would embody my invention.

Cross-int. 185. Please answer the second part of the preceding interrogatory and state whether a valve so constructed that the width of the opening would permit the pressure to rise six pounds above the eighty pounds mentioned in cross-interrogatory 178 would embody your invention.

Ans. It would, were the valve made, as stated in previous questions, like mine.

Cross-int. 186. Within what limits would a valve constructed like yours, with the opening so wide as to permit the pressure to rise above a given point, embody or contain your invention?

Ans. I do not think it would be limited as long as the stricture was variable and effectual in lifting the valve; or, in other words, when there was an appreciable static pressure, or more than impact, outside of the ground joint of the valve.

Cross-int. 187. Is that the only answer you are able to give to that question, or the only answer you think it admits of?

Ans. I think my last answer is intelligible and correct.

Cross-int. 188. Will you please answer the preceding interrogatory?

Ans. I do not see but that it is the only answer it admits of.

Cross-int. 189. Suppose the valve to be constructed "like"
143 yours, with the opening of the proper size to permit the pressure to rise eight pounds above a given pressure before it would begin to relieve the boiler; would you consider that it, the valve, then embodied your in vention?

Ans. If the valve were in perfect working order, and the pressure rose eight pounds on eight pounds, or doubled, I should not think it could embody my invention, but I have seen a common safety-valve increase as much as that on eighty pounds; that is, run from eighty to one hundred and sixty pounds.

Cross-int. 190. Please answer the preceding question, assuming the "given pressure" to be twenty-four pounds.

Ans. I think it would, if the valve lifted enough to relieve or lower the pressure in the boiler, and closed promptly.

Cross-int. 191. Would a valve so constructed, that is, with the opening so large as to allow the pressure to increase eight pounds, as stated in the preceding question, lift "enough to relieve or lower the pressure in the boiler, and close promptly," in your judgment?

Ans. It might, under certain circumstances. I have never tried it, but I think it would under some circumstances. I have never tried it with as much variation as that, as I recollect.

Cross-int. 192. Please explain what you mean by the words "under certain circumstances," and by the words "under some circumstances," in the preceding answer.

Ans. I mean by circumstances, conditions, as in a previous answer, where foam had got into the wings; and in others by the outside lift or periphery of the valve projecting down too low below the outer edge of

the seat, so that it could not get its first lift properly, as the increased tension of the spring might be too much for increased area of valve. But when a valve were in the last condition it would blow very powerfully and close suddenly.

Cross-int. 193. Do you mean to say that the valve constructed as stated in the 189th cross-interrogatory, modified as stated in the 190th cross-interrogatory, would not embody your invention except under the "circumstances" or conditions stated in answer to the 192d cross-interrogatory?

Ans. If I understand the question, I do not. I gave those con-
144 ditions to explain how the valve might act in those cases, or in explanation of the word circumstances in the previous answer.

Cross-int. 194. How did you "understand the question"?

Ans. I understood it as follows: "Do you mean that the valve as constructed in cross-interrogatory 189, modified as in cross-interrogatory 190, would not embody your invention?" My answer was, "I do not."

Cross-int. 195. Then, in your judgment, it would embody your invention whether those "circumstances" or conditions existed or not; is that so?

Ans. It would, if it raised sufficiently to give static pressure outside the ground joint to aid the valve to rise and relieve the boiler of pressure.

Cross-int. 196. Would it rise sufficiently?

Ans. I have stated in a previous answer it might. I have never tried it to know.

Cross-int. 197. What is your judgment or opinion about it?

Ans. I think it would, were the boiler making steam very fast, and reduce the pressure considerably.

Cross-int. 198. Suppose the boiler were not "making steam very fast"?

Ans. The valve would not rise to sufficient height to relieve the pressure.

Cross-int. 199. In that case the valve so constructed would not embody your invention, would it?

Ans. I think it would, but would not act as I desire it to act.

Cross-int. 200. Suppose the valve to be constructed as stated in cross-interrogatory 189, the given pressure therein mentioned being assumed to be fifty pounds, would you consider that the valve then embodied your invention?

Ans. I would.

Cross-int. 201. Suppose the pressure should rise ten pounds instead of eight; would you then consider that the valve embodied your invention?

Ans. I would, were it made like mine.

145 Cross-int. 202. The question assumes that the valve is constructed "like" yours, as stated in cross-interrogatory 189, the opening being of the proper size to permit the pressure to rise ten pounds above fifty before it would begin to relieve the boiler. With this explanation, what is your answer?

Ans. I would; for at an increase of ten pounds, or at sixty pounds pressure, it would still relieve the boiler at that point vastly more than a common valve, there being a static pressure in the annular space between the periphery and ground joint.

Cross-int. 203. That is, a valve constructed "like" yours, as stated in cross-interrogatory 189, would, in your judgment, embody your invention, although it did not begin to relieve the boiler until the pressure had

risen ten pounds above the point of fifty pounds, at which it was adjusted to begin to rise; is that so?

Ans. I think it would, for reasons stated.

DECEMBER 20, 1872.

Cross-int. 204. What do you mean by the words "variable stricture," in answer to cross-interrogatory 181?

Ans. I mean a stricture that is variable; that diminishes as the valve lifts, and increases as the valve lowers.

Cross-int. 205. Would that opening cease to be a "stricture" under any circumstances?

Ans. I think it would, when a valve of the size and construction of that on Exhibit M had raised five-sixteenths of an inch, or the distance from the ground joint to the inner edge of the periphery, or lip, of the valve. I think at that time the force exerted by the issuing steam would be only impact.

Cross-int. 206. Would the valve then embody your invention?

Ans. It would when it was on its seat; but if the lip were cut up to that distance, it certainly would not.

Cross-int. 207. Please answer the preceding interrogatory.

Ans. It would.

Cross-int. 208. How does the "static pressure" you speak of in answer to cross-interrogatory 186, that is, the static pressure outside the ground joint of the valve, operate or assist in raising the valve?

146 Ans. In a previous answer I have stated that I have known the pressure to increase with the common safety-valve from 80 to 160 lbs. While the valve was blowing at 160 lbs. there was hardly any difference in the amount of steam escaping, but apparently it only escaped with a very sharp hissing sound, and appeared not to relieve the pressure any more than at 80 lbs. There are accounts of experiments which I have read in articles copied from the proceedings of the Academy of Sciences at Vienna, 1862, of experiments by M'r Burg, in which he states the lift of a safety-valve blowing at 90 lbs. per square inch to be only 1-168th part of an inch. When the load on the safety-valve was reduced 45 lbs. it only becomes an actual or effective safety-valve. When the valve was lifted 1-6th part of an inch the pressure under the valve was diminished to five or six pounds. In my valve the stricture affects the working of the valve by causing a static pressure in the annular chamber C^{11} on Exhibit M, which pressure, in my judgment, gives nearly boiler-pressure on the whole valve inside of the ground joint, which is not the case in the common safety-valve, if the preceding experiments, or my experience, are to be relied upon.

Cross-int. 209. And that "static pressure" in the annular chamber would be substantially the same, even if the opening at what you call the stricture be greater than the opening at the ground joint when the valve is lifted, would it not?

Ans. It would, as the stricture diminishes when the valve raises.

Cross-int. 210. Then you call that a stricture, even though that opening should be twice as large as the opening at the ground joint, do you?

Ans. I do call it a stricture as long as it retards the issuing steam to make static pressure in the annular chamber C^{11} on Exhibit M.

(Witness says:)

In my answer to cross-interrogatory 208 I state that the stricture gives nearly boiler-pressure on the whole valve inside the ground joint. I wish to say it also gives me, in the conditions named, 90 lbs. of steam,

a static pressure of about 20 lbs. per square inch, or additional lifting force of about 80 lbs. in valve of the size of Exhibit M.

GEO. W. RICHARDSON.

147 *Deposition of Edwin C. Richardson.*

Direct examination by Benjamin Dean, esq., of counsel for defendant:

Int. 1. State your name, age, residence, and occupation.

Ans. Edwin C. Richardson; forty; Poultney, Vt.; merchant.

Int. 2. Are you the brother of George W. Richardson, the inventor of the Richardson steam safety-valve, and do you know anything as to the time of his inventing the same? If yes, what?

Ans. I am. I do. In the fall and winter of 1852, my brother talked with me and father in regard to a safety-valve that he was getting up, that he thought would be a great improvement on any safety-valve then in use. At this time he made a sketch or drawing of it, showing its shape or form.

Int. 3. Do you know where said sketch or drawing is, and if not, do you remember it sufficiently to enable you to make a representation of it now?

A. I do not know where said sketch is. I do remember it.

Int. 4. Please make a sketch of it. Let it be as near as possible a copy of said sketch or drawing made by your brother.

Ans. I have made a sketch which, I think, is about the thing.

(Sketch is marked "Exhibit R, J. G. S., Examiner.")

Int. 5. At that or at any other time did said Richardson make any sketch containing any other things than the valve alone as contained in sketch Exhibit R, which you have just made? If yes, what?

Ans. Well, he did; he made the part that the levers and the spring-balance as in the old-fashioned scales with flanges somewhere, as near as I could judge, they might be an inch or more from the outer lip of the valve, the flanges extending up.

Int. 6. How high were the flanges?

Ans. Well, they might have been from an inch, perhaps an inch and a half—from an inch to an inch and a half.

148 Int. 7. Can you draw a sketch representing the whole thing shown you by your brother?

A. I think I can draw it so that I could explain it to you as how it worked, but not being used to drafting, or marking with pencil or pen, things of this kind, it comes as a new business to me.

Int. 8. Please try.

Ans. Do you want me to draw the valve with the levers and spring-balance?

Int. 9. Simply draw the whole thing as well as you can.

A. I have done so and here it is.

(Drawing produced is marked "Exhibit S, J. G. S., Examiner.")

Int. 10. When was the sketch made by your brother which you have attempted to represent by Exhibit S?

Ans. In 1852.

Int. 11. Did he represent his invention by any other means? If yes, what?

Ans. He did; by veneers cut out, making a sectional model or exhibit.

Int. 12. Did he at any time make any other than sectional models of his invention?

Ans. He did; he turned one and showed it to me.

Int. 13. When was that?

Ans. That was in the fall of 1853.

Int. 14. Did your brother in 1852 say anything to you on the subject of obtaining a patent for his invention; and if yes, what?

Ans. He did; he wished me to furnish the necessary means for procuring a patent, offering me an interest in the patent.

Int. 15. Did you accept his offer?

Ans. I did not.

Int. 16. Why not?

Ans. I did not appreciate the worth of his invention, and not wishing to lose any money or to invest any in something that I knew but very little about the worth of.

Int. 17. Did he afterwards have any further talk with you on the subject of obtaining a patent? If yes, what?

149 Ans. He did; he offered me one-half of his invention if I would furnish him the necessary means to obtain a patent.

Int. 18. When was this offer?

Ans. That was in 1853, and after that at several different times we had talks in regard to obtaining a patent on it.

Int. 19. Did he ever succeed in persuading you to undertake to obtain a patent for any invention of his? If yes, what?

Ans. He did; a valve-grate for locomotive.

Int. 20. Why did you undertake to assist him in that case and decline to assist him to obtain a patent for his valve?

Ans. Because to my mind it would be a better patent, and more useful than a steam safety-valve. I could see the old fire-grates taken out and sold for old iron, when I thought if the water-grate would work as it did in the model it would be of great value, lasting for years.

Int. 21. What luck did you have with said application?

Ans. We did not get a patent.

Int. 22. What was your brother's pecuniary condition in 1852?

Ans. Well, he was owing money on house and other bills, so as he claimed he could not procure the means necessary for obtaining a patent. His family or wife was sickly, and his wages, he could but just support his family on.

MAY 4, 1872.

Int. 23. What was your brother's pecuniary condition between 1852 and 1866?

Ans. He had a good deal of sickness in his family; he had sickness and death both in his family, and to my best belief he had no spare means. It was even hard work for him to get along with the expenses of his family.

E. C. RICHARDSON.

150 *Deposition of John Daniels.*

MAY 4, 1872.

Direct examination by Benjamin Dean, esq., of counsel for defendant:

Int. 1. State your name, age, residence, and occupation.

Ans. John Daniels; fifty-four; Boston, Mass.; machinist.

Int. 2. With what concern are you connected, and what is the business of said concern? How long and in what capacity have you been so connected with them?

Ans. Hinckley & Williams; locomotive-building. I have been with the concern thirty-four years, but I have worked on locomotives thirty. At the present time I am head master-mechanic.

Int. 3. How extensive is the business of said concern?

Ans. They build at the rate of seventy locomotives a year, and employ at the rate of three hundred and fifty men.

Int. 4. What kind of safety-valves does said concern put on to locomotives, and how long have you used said safety-valves?

Ans. We put on what we call the common safety-valve till about the year 1866, and then we adopted Richardson's.

Int. 5. Did you obtain said Richardson's valves from George W. Richardson, the patentee?

Ans. George W. Richardson is the man.

Int. 6. Had you ever, before the introduction by said Richardson of his valve, used, or seen used, any other valve than the common safety-valve?

Ans. No, sir.

Int. 7. Do you now use any other than the Richardson valve?

Ans. No, sir; we use them altogether, as a general thing. Once and a while we use one common valve and one Richardson's on a locomotive, particularly for the Boston and Lowell Railroad.

Int. 8. Look at Exhibit 2 and state what it is.

Ans. I should call that the Richardson safety-valve in every sense of the word.

Int. 9. When you used the common safety-valve was there anything outside of the valve or valve-seat to turn up the steam? If yes, what was it?

151 Ans. We used what we termed an escape-pipe.

Int. 10. Look at plan marked "VI, Boston Locomotive Works, September 19th, 1853," now shown you, and state whether there are sections of safety-valves represented upon it, and from whose possession said plan came.

(Plan is marked "Exhibit T, J. G. S., Examiner.")

Ans. There are two safety-valves represented on it. That is a plan belonging to the Boston Locomotive Works—that is, it originally belonged to them, but now it belongs to Hinckley & Williams. The concern was first established under the name of Hinckley & Drury; then it became the Boston Locomotive Works, and then Hinckley & Williams—all the same concern except the management had changed. This plan represents the safety-valve which we used at the date of the plan.

Int. 11. Please explain the operation of said valve and what are the means exhibited upon it for turning up the steam.

Ans. When the valve raises the steam escapes in the escape-pipe, and the projection on the bonnet prevents it from blowing down. That projection is a ring outside of the valve and a little distance from it, against which the steam goes, and is turned up. This is shown on the drawing. The drawings are sectional drawings, and represent two valves on top of the boiler. For the first two years, 1841 and 1842, we used a plain safety-valve with an escape-pipe; since that we have used the bonnet with the projection. By bonnet I mean what you call the valve-seat. The escape-pipe, or this ring, or something like it, has always been necessary, and used to prevent the steam from blowing down and being scattered around and give it an upward turn.

Int. 12. What accomplishes that purpose in the Richardson valve?

Ans. It amounts to the same thing whether it turns it up half an inch from the valve or two inches. In the Richardson valve the outer lip of all on the valve-seat, as on Exhibit 2, is what turns up the steam, the same as the ring on the valve-seat on the plan Exhibit T.

JOHN DANIELS.

152 JANUARY 8, 1873.

Present, J. B. Robb, esq., of counsel for complainant; Benjamin Dean, esq., of counsel for respondent.

Defendant offers in evidence a certified duplicate from the records of the U. S. Patent Office of the model in the matter of the letters patent granted William Naylor, dated October 16, 1866, No. 58,962, reissued November 9, 1869, No. 3727, for safety-valves, marked "Exhibit U, J. G. S., Examiner."

Attest:

JOHN G. STETSON,
Examiner.

Agreement.—Filed February 3, 1873.

It is agreed that the following letter may be received in evidence as evidence of the fact stated therein.

JA'S. B. ROBB,
For Complainant.
BENJ. DEAN,
Defendant's Attorney.

U. S. PATENT OFFICE,
Washington, D. C., Jan. 13, 1873.

SIR: In reply to yours of the 9th inst., have to say that search has been made and it does not appear that more than one model was filed in this office in matter of William Naylor's patent for "safety-valve," issued Oct. 16th, 1866, and reissued Nov. 9th, 1869.

Respectfully,

M. D. LEGGETT,
Comm'r.

W. H. POOR, Esq.,
No. 39 *Congress street, Troy, N. Y.*

153 RESPONDENT'S EXHIBITS.

Exhibit N.—J. G. S., Examiner.

[Office of E. H. Ashcroft, manufacturer of and dealer in steam-gauges, water-gauges, low-water detectors, gauge-cocks, &c., No. 82 Sudbury street.]

BOSTON, *May* 14*th*, 1868.

Mess'rs GEO. RICHARDSON & CO., *Troy, N. Y.:*

GENTLEMEN: Yours of the 12th inst., acknowledging receipt of my letter of 28th ult., to M'r Richardson, is received. Your remarks as to the construction of my safety-valve being an infringement of your patent, is, I suppose, a random opinion, given without a knowledge of the facts in the case. Did M'r Richardson give you the letter of Patent Office examiner, refusing to allow his claim as at first made out? Do you comprehend the extent of the claims of your patent? I fully understand the extent of the claim, and I would suggest to you to send to the Patent Office for a copy of all correspondence between M'r Richardson and the office. It is not in good taste to talk about infringement where none is attempted nor intended. You do not touch upon that part of my letter which is of importance to you, viz, the reduction of price. I am of opinion that where two parties have a patent for doing a certain

thing in essentially different ways, it is advisable to avoid competition; but this you decline to consider, and I am, therefore, left to say my price of valves will be fixed and regulated by the cost of the article, allowing a fair profit, which will be far below $60 per pair.

Perhaps now it is not too late for you to examine your record, and it may possibly modify your tone somewhat.

Yours, truly,

E. H. ASHCROFT.

154 *Exhibit O.—J. G. S., Examiner.*

[Office of E. H. Ashcroft, manufacturer of and dealer in steam-gauges, water-gauges, low-water detectors, gauge-cocks, &c., No. 32 Sudbury street.]

BOSTON, *April* 28, 1868.

M'r GEO. W. RICHARDSON, *Troy, N. Y.:*

DEAR SIR: On the 21st inst., a patent was granted me for an improvement in safety-valves. The nature of the invention is in getting an increased surface for the action of the steam after it has passed the maximum point, determined beforehand by the master-mechanic. The railroads ask for a reduction in price, from a supposed competition which may exist between myself and you. Before I fix my list-price, I would like to have an interview with you. I think your price is too high, but perhaps you may be able to convince us your rate is reasonably fair.

Yours, truly,

E. H. ASHCROFT.

Exhibit P.—J. G. S., Examiner.

(Copy.)

[Office of Geo. W. Richardson & Co., proprietors of the Richardson Patent Perfect Safety Valve for locomotive, stationary, and steamboat boilers, 39 Congress street.]

TROY, N. Y., *May 12th*, 1868.

M'r E. H. ASHCROFT:

DEAR SIR: We write you to say that yours to M'r Geo. W. Richardson of the 28th April, was received, and to add, that the proprietor-
155 ship of M'r Richardson's patents for safety-valves, rests in us, Geo. W. Richardson & Co. If you are constructing safety-valves, as you describe in said letter, you are clearly infringing our patents, which you are well aware you are not at liberty to do.

Respectfully,

GEO. W. RICHARDSON & CO.

Exhibit Q.—J. G. S., Examiner.

BOSTON, *May* 4, 1868.

GEO. W. RICHARDSON, Esq., *Troy, N. Y.:*

DEAR SIR: Please give us your lowest terms for two dozen sets of your safety-valves. We understand your price is $60 per set. We can purchase Ashcroft's valve, which we consider as good as yours, for less than the above rate; we should like your lowest cash rates.

Have you any agency in this city for the sale of your valve? When do you expect to be here? An early answer will oblige,

Yours, truly,

H. J. SWEETSER & CO.,
Box 547, Boston Post-Office.

156 EVIDENCE FOR COMPLAINANT, IN REPLY.

Taken pursuant to the 67th rule of the Supreme Court of the United States, in equity, as amended, before me.

JOHN G. STETSON,
Examiner.

Deposition of James M. Blanchard.

SATURDAY, *February* 22, 1873.

Direct examination by James B. Robb, esq., of counsel for complainant:

Int. 1. State your name, age, residence, and occupation.

Ans. My name is James M. Blanchard. I am fifty-three. I reside in Washington City. I am a solicitor of patents.

Int. 2. State whether at any and at what time you were one of the examiners in the U. S. Patent Office.

Ans. I was one of the principal examiners; entered upon the duties about April 1, A. D. 1861, and continued there until July 1, 1869. From about August 1, 1861, until the time of leaving, I had charge of the class of steam-engines which embraced all of the devices in which steam is generated and used; in addition to this, for between four and five years, I had charge of the class of hydraulics, pneumatics, and hydrostatics.

Int. 3. Please state whether you have had any practical experience in the manufacture and use of steam-engines or devices in which steam is generated or used.

Ans. I have. When seventeen years of age, I was apprenticed to
157 the machinists' business; after serving three years, I was employed in a shop where steam-engines were manufactured; in 1844, I commenced running a locomotive-engine, which business I followed for about ten years, after which I was employed as master-mechanic three years, and then commenced the manufacture of locomotive and stationary engines at Springfield, in this State, which business I followed about three years.

Int. 4. Have you examined the letters patent upon which this suit is brought, and do you understand the description of the construction and mode of operation of the valve or valves therein set forth and shown?

Ans. I have examined the patent, and believe I understand the description with reference to its construction and mode of operation.

Int. 5. State how the valve marked "Exhibit No. 3," compares in construction and mode of operation with the valve described in said specification, and shown in Figures 1 and 2 of the drawings of said patent.

Ans. The valve represented by the exhibit, in so far as the parts are concerned which regulate the discharge of the steam from the generator, are substantially like those represented in the figures referred to in the question. The arrangement of the spring for holding the valve to its seat is different from that shown, in that it is located immediately above the valve in the exhibit, while in the figures referred to it is at one

side, and acts upon the valve through the medium of a lever. The mode of operation of the valve shown in the exhibit is such as is described in the specification, said specification requiring that a curved lip be placed upon the upper portion of the valve, for the purpose of deflecting the steam, after it passes the ground joint thereof downwards into an annular recess or chamber surrounding the valve-seat, from which recess or chamber a portion of the steam is to be passed out through an aperture in the casing of the valve, while the remaining portion is to pass up past the curved lip of the valve in escaping into the atmosphere. The valve represented in Exhibit 3 is so constructed as to meet these requirements, the pressure which obtains in the annular recess or chamber acting upon the under side of the curved lip for the purpose of giving the valve a greater amount of lift than it would otherwise
158 have, thus enabling it to more effectually relieve the pressure within the generator.

Int. 6. Please read the answer of William C. Hibbard, a witness on behalf of defendant, to interrogatory 5, on pages 32, 33, and 34 of the printed record, also his answer to interrogatory 6, on page 34 of the printed record, and state whether he correctly states therein the construction and mode of operation of the Naylor valve, as described and set forth in the patent aforesaid.

Ans. I have read the interrogatories and answers referred to, and am confident that in the answers the witness has not correctly described the mode of operation of the Naylor valve, for the following reasons: in his answer to interrogatory 5, among other things, he says: "The other part of the invention relates to the peculiar construction of the valve itself, whereby an increased pressure is designed to be produced upon the valve when the valve has opened and allowed the steam to escape, for the purpose of overcoming the increased resistance of the spring due to its compression by the opening of the valve"; he then states the device designed for this purpose, and adds: "It appears to have been the intention of the inventor to use the impact of the issuing steam upon the concave lip of the valve to assist in lifting it, and this alone. The annualar chamber surrounding the main opening, and into which the steam is discharged when it leaves the valve, serving no other purpose than that of a conduit for the steam." In Mr. Naylor's reissued specification he uses the following language: "I make this valve to project over the edges of the exit-passage A, and to curve its projecting edges slightly downward, as shown in Figure 1, so that the steam, on issuing between the valve and its seat, will impinge against the curved, projecting porannular chamber D, surrounding the central passage A, and communition of the valve, and a portion of it will be directed downward into the cating with the exit-pipe B, while the other portion of the steam ascends past the edge of the valve." The language employed by the witness in reference to the construction of the valve leads me to infer that he intended to be understood that all the steam discharged past the ground joint would be deflected downward into what he terms the con-
159 duit, through which the steam passes to the atmosphere. In describing this feature of the valve, he says: "This consists in forming upon the valve the concave lip, which extends some distance beyond the outside of the joint of the valve and projects downward, so that when the steam escapes from the seat of the valve it will impinge against this concave surface and be deflected downward into an annular space which surrounds the main opening of the valve in the valve-casing, and from which the steam is led away through a branch pipe." I cannot doubt that the witness intended to convey the idea that all of

the steam was to be deflected downward, and conveyed away through the branch pipe of which he speaks, especially as he says, a little further on, that the annular chamber surrounding the main opening, and into which the steam is discharged when it leaves the valve, serv*ing* no other purpose than that of a conduit for the steam. Giving, as I do, this interpretation to the language of the witness, I have no hesitation in saying, that in his answer to interrogatory 5 he has not fairly or correctly described the invention set forth in the reissued patent above referred to, for the reason——

Adjourned to Monday, February 24, at 10 a. m.

MONDAY, *February* 24, 1873.

Answer of James M. Blanchard to interrogatory 6, *resumed and completed.*

—that in said patent it is expressly stated that a portion of the steam is to pass out around the curved lip of the valve, and I find upon examining the drawing that a considerable space is shown between the outer diameter of the curved lip and the inner face or wall of chamber or recess D; and I am at a loss to understand why such a space should be provided, unless it was the intention of the inventor to provide a passage for that portion of the steam which he expressly states is to pass upward around the lip of the valve. It is clear to my mind that the inventor contemplated passing a portion of the steam, as he says, up around the lip of the valve for a specific purpose, which purpose
160 evidently was the removal of the atmospheric pressure from the upper surface of the valve when a sufficient amount of steam is passed through the opening above referred to. The effect of this current of steam would undoubtedly produce such a result, and thus prevent a current of air from being drawn downwards through said passage, and thus imposing upon the upper surface of the valve a greater weight or resistance than that due to the normal pressure of the atmosphere. In order that the steam may be allowed to pass out through the outlet B, and through the space between the lip of the valve and the chamber D, it follows that the construction of the parts is to be such as to produce that result. This may be attained in various ways, one of which would be to contract the aperture at B until it was of such dimensions as to compel a portion of the steam escaping through the ground-joint, to take an upward direction after it had been deflected downwards by the curved lip on the valve, and thus produce a pressure such as has been termed a static pressure upon the under side of said lip, thus bringing into action two effective forces for raising the valve, one of which forces would be the impingement of the steam against the under surface of the curved lip of the valve while passing it; the other being static pressure, so called, created by the steam in the chamber or reservoir D. The witness in further answering interrogatory 5, gives a description of what he terms the Richardson valve, Exhibit 2, and says: "By reason of this construction, the operation of the valve in overcoming the increased resistance of the spring is very efficient, and prevents the pressure of the steam in the boiler from exceeding that required for opening the valve. This mode of operation is not in any degree to be found in the Naylor valve; the steam escaping from this valve simply impinges against the concave surface of the lip, and is deflected downward by it into the annular space around the valve, and as the weight of the steam escaping is so exceedingly small, its momentum, so far as it is expanded on the interior of the lip, is also exceedingly small, and

by no means sufficient to produce the result, or in other words, the additional pressure upon the valve that is required to overcome the increasing resistance of the spring due to the rising of the valve to open it." The witness in giving the opinion above referred to, has
161 evidently misstated the operation of the Naylor valve, because in such valve there is a pressure operating upon the under side of the curved lip, which pressure is equal to, or greater than, that operating upon the under surface of the Richardson valve, with which the comparison is made. Another error of the witness in this answer evidently is, that he attaches too little importance to the impinging action of the steam upon the under side of the curved lip of both of the valves referred to, for the reason that the distance between the ground-joint and the point where the steam strikes the curved lip is so small as to make it certain that the force exerted by the impinging steam would be considerable, and of course, to the extent of such force, would aid in opening the valve.

The witness further says, that "There is nothing about the construction of this valve to prevent the free escape of the steam into the atmosphere after it has left the ground-joint of the valve, and therefore no such pressure of the steam can be produced upon the lip as is produced by the obstruction of the free passage of the steam by a stricture, as is the case in the Richardson valve, and to which entirely, in my judgment, the Richardson valve owes its efficiency." This statement of the witness, I feel confident, is erroneous, because it is a fact which I believe is admitted on all sides, that the steam which passes the ground-joint in the Naylor valve is deflected downwards, and, consequently, when thus directed, its tendency is to travel in a straight line until it reaches the bottom of chamber or recess D, wherever that may be placed, and that upon striking the bottom of said recess or chamber, its reaction would be equal to the force with which it is driven downwards, thus causing said recess or chamber to be filled with steam with a considerable degree of pressure, and afterwards passed out through the aperture B, and around the curved lip of the valve, as described in the specification. The arresting of the motion of the steam in the recess or chamber D, would act, to all intents and purposes, as a stricture or obstruction to the steam, and would consequently cause said recess or chamber to be filled with steam at a considerable pressure, notwithstanding the fact that the
162 aperture B, when made as directed in the specification, should be fully opened, said specification directing that it be so constructed as to pass a portion of the steam up around the lips of the valve, the amount thus directed upwards being according to the size of the valve, and the volume of steam to be passed through it may be regulated by the area given to the aperture B. The 6th interrogatory reads as follows: "You say the annular space in the Naylor valve serves only as a conduit to take off the steam; does all the steam escaping from the valve pass through said conduit? Explain its mode of operation in this respect." The witness answered: "It does; it not only directs all the steam downwards, but also a strong current of air downward, through the space between the valve and the valve-casing, or the outer boundary of the annular space, mentioned in my previous answer." This portion of the answer of the witness cannot, as I understand it, be a correct description of the Naylor valve, because he asserts that all the steam would be directed downwards, while the specification expressly states that a portion of it is to be directed upwards, and the drawing shows one form of construction which would thus direct the steam. What the witness says of a valve constructed as he claims the Naylor valve should be, is, I have

no doubt, correct. If all the steam which passes the ground joint should be allowed to pass out through the aperture B, it is apparent that a current of air would be drawn in around the curved lip of the valve, and thus an indefinite amount of additional resistance would be placed upon the valve which would vary according to the velocity with which the steam should pass out into the atmosphere. This additional resistance would not be a determinable quantity, except at a given pressure within the generator, and a given velocity at which it should pass out into the atmosphere. Such a form of construction would make a valve of comparatively small value, for the reason that it would not correctly indicate the pressure within the generator, except when such pressure was at the precise point, with reference to which the valve had been constructed.

Int. 7. Please state whether you have witnessed the practical working of the safety-valve constructed according to the specification of the said reissued patent. If yea, state how it operates in actual practice in relieving the pressure of steam in the boiler.

Ans. I have witnessed the operation of the valve constructed
163 in accordance with the instructions given in the reissued specification referred to, the valve being arranged to commence rising from its seat sufficiently far to allow a small quantity of steam to issue therefrom when the steam-gauge indicated sixty pounds of pressure; the valve remaining very nearly in this position, there being only a slight difference perceptible in the amount of steam connected, until the gauge indicated sixty-one and one-fourth pounds, when there was a sudden upward movement of the valve, and a large volume of steam passed out through the aperture which in the patent is designated by the letter B, and at the same time a volume of steam passed out through the aperture between the covered lip and the outer casing of the valve, which volume, as near as I could determine, was equal to that flowing out through aperture B; the valve remained in this elevated position until the steam in the boiler, as indicated by the gauge, was reduced to a pressure of sixty pounds, when the valve suddenly closed. The lift of the valve, as indicated by very nicely constructed instruments made for the purpose, was fully three-sixteenths of an inch; during the time the valve remained open, no perceptible increase of pressure obtained within the boiler.

Int. 8. Please examine defendant's exhibit G, being that referred to in interrogatory 16 and 17, of M'r Hibbard's deposition, and read his answers thereto, in which he states the construction and operation of said exhibit on pages 38 and 39 of the printed record, and say whether that exhibit is constructed in accordance with the directions given in said reissued patent for the construction of the Naylor valve; and if not, wherein does it differ from the Naylor valve as described in the specification?

Ans. I have examined the exhibit referred to in the question and find it to differ essentially from the instructions given in the reissued patent; first, because the aperture B is of such dimensions as to admit all the steam deflected downward by the curved lip upon the valve to pass out through it without being retained in, or obstructed in its passage through the recess or chamber D, sufficiently long to cause a pressure therein which would force a portion of it to pass up through the aperture formed by the curved lip of the valve and the casing, as is re-
164 quired to be done by the said reissued specification, said specification making it obligatory upon the constructor to contract the nozzle B, or in some other way obstruct the passage of the steam in its

passage to the atmosphere, to such an extent as to compel a portion of it to pass upwards as above described. In answer to interrogatory 17 the witness states that "the steam all passed downward into the annular space around the central opening of the valve and was discharged from the tin pipe at the side, and there appeared to be a strong current of air flowing downward past the valve into the annular chamber." It is difficult to reconcile what the witness here says with the instructions given in the specification and at the same time assume that Exhibit G is constructed in accordance with said specification, because it is there stated that a portion of the steam is to pass up around the valve, while he expressly states that no part of it did pass in that direction, but that it all flowed out through the aperture B. The witness further states "that there appeared to be a strong current of air flowing downward past the valve into the chamber, which was indicated clearly by holding bits of paper a little above the valve, an inch or an inch and a half or so, which were drawn in past the valve with great velocity." I have no doubt of the correctness of the last referred to portion of the testimony, as the result is precisely what ought to be expected from a valve constructed like Exhibit G.

Int. 9. (De bene esse.) Please read the description of the valve having any overhanging lip described in defendant's exhibit C, on pages 78 to 85 of the printed record, and state how it compares substantially with complainant's exhibit No. 3, in construction and mode of operation.

Ans. I have examined the exhibit referred to, as well as that portion of the specification embraced in the question, and I find that the inventor describes on page 79, a valve "having the edges outside the valve seating, cupped, or turned downwards, so that the main body of the steam as it escapes from the boiler, being directed downwards, strikes against the bottom of a suitable recess or into a chamber round the pipe, leading from the boiler to the valve, and consequently
165 the recoiling action of the steam acts upwards against the under surface of the valve as it issues forth into the atmosphere; and by such recoiling action of the steam the valve is arrested in opening, so as to counteract the resistance of the atmosphere to the issuing steam, which resistance is virtually equal to an extra load on the valve. I find this language employed in what is usually termed the declaration of the nature of the invention, which is to follow in the remainder of the specification.

On page 81, the inventor employs the following language: "A is the main thoroughfare leading direct from the boiler; B is a lateral branch or escape passage for a portion of the steam after it has passed the valve C. I prefer to make this valve project over the edges of the exit passage A, and to curve the projecting edges of the valve slightly downwards as shown in the drawing (Fig. 1), so that the steam in issuing between the valve and its seat will impinge against the curved projecting portion of the valve, and a portion of it will be directed downwards into the annular chamber D, surrounding the central passage A, which chamber D communicates at once with the branch exit pipe B, whilst the other portion of the steam ascends past the edges of the valve; by this means I am enabled to avail myself of the recoil action of the steam against the valve, for the purpose of facilitating the further lifting of such valve when once opened." Upon examining Exhibit 3, I find it contains a valve with an overhanging lip, so arranged as to direct the steam into a suitable recess or chamber, in which by its recoil action or expansive force it does aid in raising the valve as described in the specification. I also find that this valve is provided with a nozzle -

B, through which a portion of the steam which passes the ground join of the valve escapes into the atmosphere. That portion of the steam which escapes up around the curved lip of the valve, being in my judgment sufficient in volume and velocity to produce the effect spoken of in the specification, namely, the atmospheric pressure or the largest portion thereof from the upper surface of the valve. From this examination and comparison, I have no hesitation in saying that the valve marked "Complainant's Exhibit 3," shows a valve constructed substantially in accordance with the requirements of the specifica-
166 tion referred to, and that its mode of operation fully meets the requirements of said specification.

Adjourned to Tuesday, February 25th, at 10 a. m.

TUESDAY, *February* 25—10 a. m.

Int. 10. Can you state with any degree of positiveness the amount of static pressure, so called, in the "recess" or "annular chamber" of the Naylor valve, when the valve is blowing off steam?

Ans. I can. I have recently made an experiment with a view of demonstrating the static pressure in the different parts of such recess or chamber, the experiment being made upon a valve in all respects like that marked "Complainant's Exhibit 3." This experiment was made by attaching to the upper portion of the recess or chamber a steam gauge, and by attaching another to the lower portion thereof, the last-named one being as nearly as possible the centre of the outlet passage B; in this condition the valve was placed upon a pipe communicating directly with the steam-generator, and the spring was compressed by the screws until the gauge attached to the generator indicated sixty pounds of pressure, when the pressure in the generator was allowed to increase until the valve popped or suddenly raised as in the previous experiments, at which time the pressure in the recess or chamber was noted; the gauge attached to the upper portion indicating a pressure of thirty-nine pounds, while the one attached to the lower portion indicated a pressure of twenty-three pounds. This experiment was carefully made, and I have no doubt that it correctly represents the static pressure that would be acting upon the under side of the curved lip of the valve at such times. The pressure indicated by the gauge upon the generator within thirty seconds of the time the valve "popped" was sixty-three pounds.

Int. 11. Please examine defendant's exhibit A, being English letters patent granted to Charles Beyer, No. 1038, sealed October 16th, 1863, and state whether you find therein the invention described in the reissued patent upon which this suit is brought.

167 Ans. I have examined the patent referred to in the question, and do not find it to describe or show the invention described in the reissued letters patent referred to in the question. There is shown in this Beyer's patent a valve with an overhanging lip, the avowed purpose of which is to assist in opening the valve, but any steam escaping from such a valve would resist the upward movements thereof just to the extent of the pressure that should obtain within the chamber, or "hood," in which the valve is placed, all the steam escaping from the valve being compelled to pass through this chamber, or "hood," and through an outlet upon its under surface in the atmosphere; which out, side pressure would offer considerable resistance to the rising movement of the valve, and would, in my judgment, be nearly or quite equal, when discharging a large volume of steam at a high pressure, to the pressure

or force exerted upon the under side of the overhanging lip of the valve. In speaking of this invention, it is stated that "this improved valve will, as before stated, lift promptly when the required pressure is attained, and will open to a much greater extent than the common safety-valve. Extra pressure upon the valve will readily close it after it has lifted, but it does not shut self-acting until the pressure in the boiler has diminished several pounds below the pressure at which the valve was lifted." "To cause the safety-valve when it has been lifted by the excess of pressure to close again, self-acting, when the pressure has diminished to a given extent, the inventor employed the additional apparatus, which is also shown upon the accompanying drawings in connection with his improved valve." In addition to the difference heretofore pointed out between this valve and the one described in the reissued specification referred to in the question, this inability to close automatically or without the aid of additional apparatus makes the difference between the two very apparent, as when placed in position, as, for instance, on a locomotive-generator, the additional apparatus would be very cumbersome and expensive, and any attempt to use the valve for such a purpose, without said additional apparatus, would, according to the inventor's own admission, be attended with difficulty and with a considerable loss of steam.

168 Int. 12. Can you state how the Beyer valve operates in rising in actual practice? If yea, please do.

Ans. I think I can. When the valve is in its proper position, it rests upon its seat like an ordinary valve, it being held in contact therewith by some suitable mechanism. When a pressure has been generated in the boiler it acts upon the under surface of the valve, and when it exerts the requisite amount of force to start the valve from its seat, a thin film of steam passes the ground joint and impinges agaist the under surface of the curved lip of the valve, thus aiding, to the extent of its impinging force, in giving the valve a further movement upwards; when the last-named movement has occurred, a large quantity of steam, compared with what was before passing the ground joint, is allowed to flow out, which steam accumulates in the "hood," or chamber, and fills it with steam at a certain pressure, which pressure, as a matter of course, acts in all directions alike; so that any part of this pressure, which would otherwise be utilized in acting upon the under surface of the curved lip of the valve, is neutralized effectively by the downward pressure upon the upper surface of said valve. In this view of the case, which I feel confident is the correct one, the only force which can be brought to bear outside of the ground joint, is the impinging force of the steam as it strikes against the curved lip, and in this respect it differs essentially from the so-called Naylor valve, because that, in that valve there are two forces in operation at one and the same time, the first being the impinging force, as in the Beyer's patent; the second being the static force of the steam, so called, referred to as having been proven to exist, as shown by experiment. It will be understood that the steam passing through this valve, after it has performed its office in the hood or chamber, passes out through an aperture therein into the atmosphere or into a suitable pipe for conducting it to any desired locality.

Int. 13. Can you state how high that valve rises in actual practice from any and what experiments made by you?

Ans. I made an experiment on the 6th or 7th day of January last upon a valve constructed in accordance with the specification and drawings of the Beyer's patent, for the purpose, among other

169 things, of determining the lift of this valve; at which time I care-

fully noted in the memorandum-book which I now have in my hand the amount of lift, or the distance travelled through in rising of this valve under a pressure of seventy pounds, as indicated by the gauge on the generator to which the valve was attached, and found it to be 1-32d of an inch. The amount of lift in this case was ascertained by a very delicately-constructed instrument having a sliding-bar, which, before the valve had been affected by the heat or steam, was made to rest upon the upper end of the valve-spindle in such a manner as to be carried up with the valve, in which position it was retained by a spring, so that after the steam had been shut off from the valve, and it had fallen to its seat, the distance between the upper end of the valve-spindle, and the lower end of the sliding bar could be accurately measured, and there the exact amount of lift or upward movement of the valve determined.

Int. 14. How high did the pressure in the boiler rise during that experiment, and how did the valve work compared with the ordinary safety-valve?

Ans. The pressure rose to eighty pounds. The valve in its operation was, so far as could be observed, like the ordinary valve, its upward movement being a gradual one from the time it commenced rising at seventy pounds pressure until it reached its highest point, when the pressure of the steam in the generator was prevented from being increased, and, the pressure gradually diminishing, the valve gradually descended until it reached its seat. The time occupied in raising the pressure from the point at which the valve commenced to blow to its highest point was five minutes.

Int. 15. In answer to interrogatory 5 of M'r Hibbard, on pages 32, 33, and 34 of the printed record, he compares the operation of the valve Exhibit 2 with the valve which he calls the Naylor valve, constructed in the manner stated by him in that answer. Please state whether there is any substantial difference between Exhibit 2, in its mode of operation as a safety-valve, and the Naylor valve constructed according to the specification of the said reissued patent, on which this suit is founded?

Ans. I do not think there is any substantial difference in the
170 mode of operation of the two valves, both of which depend upon the impinging force of the steam against an under-curved lip and upon a so-called static pressure in a chamber or recess below said lip; there is, however, a slight difference in the construction of the chambers or recesses of the two valves, this difference relating however to dimensions only, it having no reference to or producing any different effect upon the valve in raising it from its seat. In comparing these valves, with a view of ascertaining the mode of operation of each of them, I find that the valve Exhibit 2 has, first, a seat upon its casing which has been termed the ground joint; outside of this ground joint there is a curved downwardly-projecting lip, which, together with the upper surface of the valve-casing, directs the steam which escapes past the ground joint into a recess or chamber below the lip of the valve. Upon examining the valve described in the reissued patent referred to, I find the same features referred to in the description above given of Exhibit 2, and I further find that these parts are so arranged as to produce the same or similar results in both cases, the mode of operation being that the steam after passing the ground joint impinges against the under sur*surface* of the curved lip, thus affording one method of applying the power necessary to raise the valve the proper distance to relieve the pressure in the generator, after which the steam in both cases is directed downwards into a recess or chamber surrounding the valve-seat, and in which recess

or chamber it is retained until it produces what has been termed a static pressure, which pressure is exerted upon the under side of the lip of the valve, and, in conjunction with the impinging force above referred to, accomplishes the desired results, namely, the lifting of the valve to such an extent as to relieve the generator from any increased pressure which may obtain within it. I have found by experiment that the difference in the static pressure which is produced in the recesses or chambers of the two valves is largely in favor of the valve described in said reissued patent, it being, as before stated, thirty-nine pounds in the upper portion of the recess surrounding the valve-seat and twenty-three pounds in the lower portion, while in a valve constructed like Exhibit 2, an
171 experiment made with the same gauge which indicated the thirty-nine pounds above referred to, said gauge being connected to the valve, like Exhibit 2, directly over the recess in said valve, indicated a pressure of twelve pounds. The pressure at which the valves in both of the abovenamed experiments were set to commence rising was sixty pounds, as indicated by the guage on the generator; the point at which the valves suddenly raised varied about two pounds, it being sixty-two and a small fraction in the valve constructed in accordance with the reissued patent, and sixty-four in the valve like Exhibit 2.

Int. 16. Did you try an experiment with the valve like Exhibit 2, with any and what portion of the cup turned off? If, yea, with what effect?

Ans. I did try an experiment with that portion of the casing which projects upwardly outside of the outer recess or chamber, turned off down as far as the bottom of said recess or chamber, it being bevelled downwards at an angle of, say 45° to the outer edge of the valve casing. In this experiment, the same valve was used as in the one above referred to, as was also the same gauge and connecting pipe; the pressure of the steam in the generator, when the valve commenced rising from its seat, was about 63 pounds. When the valve suddenly rose, the pressure indicated by the gauge on the valve was 15 pounds, the pressure in the boiler being 65½ pounds, as nearly as I can state.

(Recess of one hour.)

Int. 17. Please say whether you desire to make any correction in the preceding answer. If yea, state what it is.

Ans. I do, for the reason, that during the recess I have had my attention called to a conversation which occurred while the valve was being prepared for the last experiment spoken of in my answer to the last interrogatory, which conversation I now distinctly remember, and which was as follows: One of the parties present remarked that he did not think that the valve would "pop" at all with that portion of it turned off which I have described; another of the parties remarked that it would if we would give it time enough; after this the valve was placed upon the generator and set to commence rising, as above described, and
172 I recollect distinctly that a considerable space of time elapsed before the valve "popped," and in order to refresh my memory with reference to the pressure which obtained in the generator before the valve did suddenly rise, I have during the recess which has just occurred, had the experiment repeated, and the correction which I wish to make is in reference to the pressure in the generator at the time the valve "popped," which pressure I find to have been between 69½ and 70 pounds; and I now recollect that upon looking at the guage immediately after the valve rose suddenly in the previous experiment, that it indicated a pressure of 70 pounds. The valve tried during the recess is the same as that tried on the previous occasion referred to, and is, as I believe, in the same condition that it then was; it having been placed upon

the generator without any alteration or adjustment, and commenced to rise at 63 pounds, as it did previously, and so far as I am able to judge, the time required to increase the pressure in the generator was the same, or very nearly the same as on the previous occasion.

Cross examination by Benjamin Dean, esq., of counsel for defendant:

Cross-int. 18. Where are the various valves with which you tried the experiments you have testified about?

Ans. One of them is here present, and is marked "Complainant's Exhibit, No. 3"; where the others are I do not know, but I believe that some of them are here present, and I do not know but that they are all here.

Cross-int. 19. Has any of them, except Complainant's Exhibit 3, been present in this room so as to be seen by yourself while giving your testimony?

Ans. They have not.

Cross-int. 20. Is either of them, except said Exhibit 3, present in this room, so as to be seen?

Ans. They are not.

(Adjourned until Wednesday, February 26, 10 a. m.)

173 WEDNESDAY, *February* 26, 10 a. m.

Cross int. 21. Where did you try the several experiments about which you have testified?

Ans. On the premises of M'r Ashcroft, in this city.

Cross-int. 22. Of the plaintiff in this case?

Ans. Yes; I suppose him to be such; it was on the premises of M'r E. N. Ashcroft.

Cross-int. 23. When did you try said several experiments?

Ans. The experiments made with the Beyer valve, so called, were made on the 6th and 7th of January last; those made with the valve Exhibit 3, and those made with a view of testing the pressure in the recesses around the valves, were made on the 21st day of the present month.

Cross-int. 24. Who were present, and who assisted in the experiments on the 6th and 7th of January?

Ans. M'r Ashcroft was present during a portion of the time; his engineer and fireman were also present, and the foreman of one of his shops. The engineer and foreman assisted in making the experiments, so far as to place the valves upon the generator and to remove them therefrom.

Cross-int. 25. Who were present and assisted in making the experiments on the 21st of the present month?

Ans. The same parties were present, with the exception of the engineer, who I think is not the one that was in charge of the engine when the previous experiments were made; but of this I am not certain. The foreman of the shop, before alluded to, assisted in this case to the same extent that he did in the previous one.

Cross-int. 26. Were the same persons present at the experiment made yesterday?

Ans. They were with the exception of the engineer, who I learned had been sent out of town for some purpose.

Cross-int. 27. What was the size and capacity of the steam generator used in these experiments?

Ans. I can only answer this question by giving my judgment in reference to it, as I did not measure it, but believe it to have been about five feet in diameter by about twenty-four feet in length.

174 Cross-int. 28. Would it make steam as fast as a first-class locomotive boiler?

Ans. With the blower in operation as it was most of the time, during the time these experiments were being made, I should say that it would generate more steam, in a given period of time, than a first-class locomotive boiler could be made do, while the locomotive was in a state of rest.

Cross-int. 29. You have stated that the valves were attached, for the purpose of the experiments, to the pipe connected with the generator; were the valves in each case attached to the same pipe?

Ans. They were in every instance.

Cross-int. 30. What was the diameter of the inside of said pipe, and what was the distance between it and the generator?

Ans. I did not measure the pipe, but believe it to have been two inches upon the inside; at any rate, it was such a pipe as that its outer diameter, when a thread was cut upon it, would fit the lower nozzle of the valve Exhibit 3; its distance from the point when the steam was taken from the generator was, as nearly as I can estimate it, four feet.

Cross-int. 31. Was there any turn in said pipe?

Ans. There was one elbow, and I think one right angle turn; the latter being at the point where the valve was screwed on to the nipple in the pipe.

Cross-int. 32. Where was the elbow?

Ans. At the point where the direction of the steam-pipe was changed to bring it outwards to the side of the arch of the generator.

Cross-int. 33. How far from the attachment to the valve was the elbow of which you have spoken?

Ans. I prefer, before answering this question, to make an examination and take measurements, so as to be able to answer it intelligibly.

Cross int. 34. Was the pipe of the same diameter throughout its length between the generator and the valve?

Ans. I cannot answer this question, as a portion of the pipe into which the steam entered from the generator was not in sight from the position which I occupied in making the experiments.

175 Cross-int. 35. Was there a stop-valve; and, if yes, how far from its attachment to the valve on which the experiments were made?

Ans. There was a stop-valve, and I should say that it was two and one-half feet from the valve on which the experiments were made.

Cross-int. 36. Was that stop-valve used to turn the steam up to the valves on which the experiments were made?

Ans. It was not; it was used to form a communication between the generator and the pipe which led to the valves.

Cross-int. 37. Was there any other stop-valve in the pipe?

Ans. There was not.

Cross-int. 38. Was that closed to permit the valves to be changed?

Ans. It was.

Cross int. 39. Who manipulated that stop-valve for the purpose of the experiments?

Ans. The engineer, with the exception of the last one, in which the foreman before referred to operated it. I may as well say here that the engineer and foreman were more than once instructed to and did open the valve to its full capacity, while trying all of the experiments.

Cross-int. 40. Where were you stationed for the purpose of witnessing the experiments?

Ans. On the side of the brick-work composing the setting of the

boiler, and at about six feet from the front end of said boiler; I would say, however, that during those experiments that related to the difference of pressure in the boiler, between the times when the valve first started from its seat, and when it "popped," or suddenly rose, I was stationed directly in front of the boiler where the gauge which indicated the pressure was placed; this gauge being attached directly to the front end of the boiler near where I stood; from the position which I occupied, I could at the same time distinctly see the gauge and the valve, without changing my position.

Cross-int. 41. How much time would it take for you to make the examination to enable you to describe the pipe used to connect the valves with the boiler, as you would like?

176 Ans. I should say to go from here to where the boiler is located, make the examination, and return, would require one hour's time.

Cross-int. 42. Have you now examined the pipe enquired about sufficiently to describe it and its connections? If yea, please do so.

Ans. I have examined it, and find that the steam is taken from the generator through a pipe which is three inches in its internal diameter, and that the distance from where it leaves the generator to the point where the valves were placed in making the experiments is about 7 feet, and that in this pipe, counting the turn immediately over the boiler, there are three turns at a right angle, and one which is made by an elbow, or quarter turn, the latter being a curve around which the steam passes.

Cross-int. 43. Do you mean 7 feet to the perpendicular pipe connecting immediately with the boiler?

Ans. I do; to the centre of that pipe.

Cross-int. 44. Opposite said last-named connection, is there, or not, another pipe connecting with said perpendicular pipe? And, if yes, of what size, and for what purpose is it used?

Ans. There is such a pipe, its diameter being the same as the one above referred to, and having in it a stop-valve, which I believe is for the purpose of letting steam into the building for warming the rooms therein; but this valve was never open at the same time that the valve in the pipe leading to the valves that were being experimented with was open, and hence no effect was produced upon the valves being experimented upon, in consequence of there being such a pipe as is referred to in the question.

Cross-int. 45. Does the pipe referred to in the question serve no other purpose than that you have mentioned in your last answer?

Ans. I think a portion of it is used for conveying steam to the engine.

Cross-int. 46. Was it so used during the experiments you have testified about?

Ans. If I am right in saying that a portion of this pipe is used in conveying steam to the engine, then it was so used during such experiments; it being a fact that the engine was in operation while the experiments were being made.

177 Cross-int. 47. How large is the pipe carrying steam to the engine?

Ans. I am not able to say, nor am I able to perceive that it would make any difference in the result obtained in the experiments whether it was one inch in diameter, or any number of inches more than one, so long as the generator furnished steam in sufficient quantities to maintain the pressure in said pipe, and in the pipe to which the valves

were attached, which was the case during all the time these experiments were being made.

Cross-int. 48. What was the longest time that any valve remained open during said experiments, after it commenced discharging steam rapidly?

Ans. I did not take any note of the time that the valves did remain open; it, however, was a short period of time, but sufficiently long in the trial of the valve Exhibit 3, and in the valve which I have described as being constructed like the Richardson valve, to determine the fact that the pressure was being reduced in the generator.

Cross-int. 49. Did you take no note of the length of time that either of the valves remained open during the experiments?

Ans. I did not.

Cross-int. 50. Did you estimate it at the time of the experiments?

Ans. I did not; but simply permitted the valves to remain open until the gauge upon the generator clearly indicated a diminution of pressure, and then caused the stop-valve to be closed in the pipe which led the steam from the generator to the valve being experimented upon.

Cross-int. 51. What is the capacity of the engine supplied by that boiler?

Ans. I can only answer this question by stating that I have heard M'r Ashcroft say that it was from thirty to thirty-five horse-power; I have never measured the diameter of the cylinder or the length of the stroke, nor do I know the number of revolutions which the engine makes in any given period of time.

Cross-int. 52. Have you ascertained the size of the boiler?

178 Ans. I have not by measurement; but understand M'r Ashcroft to say that it is 54 or 56 inches in diameter and 16 feet in length.

Cross-Int. 53. Would that be your own judgment, as the result of your last examination?

Ans. It would.

Cross-int. 54. What was the largest relief to the boiler in any of the experiments you made?

Ans. As nearly as I can state, the valve was allowed to discharge steam until the pressure in the boiler had been reduced seven pounds.

Cross-int. 55. What did you do then?

Ans. Closed the stop-valve in the pipe leading to the valve that was being experimented with.

Cross-int. 56. With what valve were you then experimenting?

Ans. With the Naylor valve, so called.

Cross-int. 57. Is that valve present? If yes, which is it?

Ans. It is; it is marked "Exhibit 3."

Cross-int. 58. Did you try any other experiments with that exhibit?

Ans. I did not.

Cross-int. 59. Why did you not let it go on to see how far it would reduce the pressure in the boiler before it closed automatically?

Ans. I did not intend to be understood as saying that the stop-valve was closed previous to the closing of the safety-valve.

Cross-int. 60. Do you mean to say that in the experiment by exhibit 3, the valve closed automatically after it had reduced the pressure seven pounds?

Ans. I was mistaken in saying that the valve by which the pressure was reduced seven pounds in the generator was Exhibit 3; the fact being that it was another valve purporting to be constructed in accordance with the reissued patent upon which this suit is brought; the

valve Exhibit 3, as I have before stated, did not reduce the pressure in the boiler more than 1 1–4 pounds below that at which it opened, before it closed.

Cross-int. 61. 1 1–4 pounds below what? Below the pressure at which it first let off steam, or below the pressure at the time when it popped, or raised suddenly?

179 Ans. I mean below the pressure at which it "popped" or rose suddenly.

Cross-int. 62. What was the difference in pressure between the time when it began to let off steam and the time it "popped" or rose suddenly?

Ans. I find upon referring to my memorandum that it was set to blow very slightly at 60 lbs. pressure, "popped" at 61¼ lbs. and closed suddenly at 61 lbs.

Cross-int. 63. Was the stop-valve then closed?

Ans. It was closed immediately after the safety-valve had closed.

Cross-int. 64. Was any steam escaping from the safety-valve at the time the stop-valve was closed?

Ans. There was to all appearance a slightly greater volume than that which was escaping before the valve suddenly rose; but as to the amount or volume I cannot speak with any certainty, as the time between the closing of the stop-valve and the dropping of the safety-valve was so short.

Cross-int. 65. Was any one stationed at the stop-valve ready to close it?

Ans. There was.

Cross-int. 66. Who?

Ans. M'r Ashcroft's engineer, in this case, whose name I do not know.

Cross-int. 67. His present engineer or a previous one?

Ans. His present one, or the one who was in charge of the engine, as it appeared to me, and as I believe to be the fact, on the 21st day of the present month.

Cross-int. 68. Who ordered him to close the stop-valve?

Ans. M'r Ashcroft instructed him to stand in the proper position so that he could close it, and I instructed him when to close it.

Cross-int. 69. You made no other experiments with that valve, did you?

Ans. I did not.

Cross-int. 70. Where now is the valve which purported to be made according to the plaintiff's reissued patent in this case, and which reduced the pressure in the boiler seven pounds.

180 Ans. I have no knowledge of its whereabouts, as that experiment was made on the 26th or 27th of January last, and I have not seen nor heard of it since.

Cross-int. 71. In what respect did it differ from Complainant's Exhibit 3?

Ans. I am not able to answer the question, as I did not take the valve apart and examine its internal arrangements; but, as I stated in answer to a previous question, it purported to have been made in accordance with the reissued specification upon which this suit is brought.

Cross-int. 72. Was M'r Ashcroft present at the trying of that experiment?

Ans. I think he was, as I recollect his having said that we would try that valve with the rest with which we were experimenting, but that he did not think that the trial would be a satisfactory one, as he

did not regard the valve perfect in all its parts. I remarked to him that I thought it might be well to try it, and that we could at some future time make other experiments with valves more perfect in their construction.

Cross-int. 73. Did he tell you at that same conversation of which you have spoken that it was made according to his reissued patent in this case?

Ans. He did not.

Cross-int. 74. Who did?

Ans. There were several valves standing together in M'r Ashcroft's sales-room, and we were conversing in reference to them; and, among others, I pointed to this valve, and asked him what valve that was; and he remarked that it was a Naylor valve, but that he did not regard it as a perfect valve; and it was this conversation which led me to say that it purported to be constructed according to the reissued specification on which this suit was brought. This was when I first saw the valve to be experimented upon and before I had examined any of them.

Cross-int. 75. Was that all that was said about it or done with it?

Ans. It was not.

181 Cross-int. 76. What else was said about it or done with it?

Ans. After having tried some experiments with other valves M'r Ashcroft repeated substantially what he had before said, and I then told him that I thought it would be well to test it, as I have explained in answer to a previous question.

Cross-int. 77. Have you now told all that was said about or done with that valve?

Ans. I have told all that was said about it and all that was done with it, so far as I know.

Cross-int. 78. You say you did not examine it internally; did it resemble Complainant's Exhibit 3 externally?

Ans. It did; except, if I remember correctly, it was made of iron instead of being made of brass I mean the casing; and everything except the valve and its seat, the springs in both instances being of steel.

Cross-int. 79. Is the valve in which, upon experiment, you found a pressure of thirty-nine pounds in the upper part of the chamber and twenty-three pounds in the lower part of the chamber, present?

Ans. It is; on the table before you, marked "Exhibit 4."

Cross-int. 80. When were the experiments made with that valve and how many did you make?

Ans. Made on the 24th day of this month; I made only one.

Cross-int. 81. What was the pressure indicated by the gauge on the boiler when that valve closed?

Ans. In this experiment we did not wait for the valve to close automatically, but as soon as we had ascertained the pressure in the recess the steam was shut off by the stop-valve.

Cross-int. 82. How long was that after the valve "popped" or suddenly raised?

Ans. I should say from one to two minutes; I did not take any account of the time, as the object was to ascertain the pressure in the recess at the time when and immediately after the valve had raised suddenly.

Cross-int. 83. Did you notice whether the pressure was rising or falling in the boiler?

Ans. I did not.

182 Cross-int. 84. Did you permit it to blow a longer or shorter time than was the case in the experiment on Exhibit 3?

Ans. I should say a shorter time.

Cross-int. 85. How much shorter?

Ans. I cannot state; I answered the previous question from recollection only, and cannot undertake to give the precise time in either case.

Cross-int. 86. Was the opening into the atmosphere on the side of the valve as large and as unobstructed during that experiment as it is now in said Exhibit 4, on which the experiment was made?

Ans. It was just as you see it before you.

Cross-int. 87. How high did the valve rise when the pressure in the chamber or chambers indicated thirty-nine and twenty-three pounds?

Ans. I did not take any measures to ascertain the lift of the valve, and can only say that, judging from the volume of steam that was escaping, it rose as high as did the valve in Exhibit 3 when it was measured and found to be fully three-sixteenths of an inch.

Cross-int. 88. What, in your judgment, was the pressure when said valve was blowing, after it had risen suddenly, under the said valve and inside of the ground joint?

Ans. I suppose it to have been very nearly equal to the pressure in the generator; in my judgment there could not have been any perceptible difference, or but a very slight difference, if perceptible, between the pressure upon the surface of the generator and the under side of the valve; theoretically speaking, there would have been a slight diminution of pressure upon the surface of the valve, owing to the fact that the steam in passing from the generator to the valve in which the experiment was being made had to pass the right angle turns and the circular turn of which I have before spoken, and owing to the further fact that a very slight reduction of pressure at the point where the valve was located would be caused by the friction of the steam in passing through the pipe. These causes would be sufficient in such a pipe, if the outflow of the steam from the end thereof was unobstructed, to cause what might be termed a practical diminution of pressure at
183 the end of, but just within, the pipe; but, as in this case, the outlet to the atmosphere was so restricted that only a small portion of the steam which the pipe was capable of conveying to the valve in a given period of time could pass that point, the reduction of pressure upon the under side of the valve would not amount to a practical reduction, and could not, in my judgment, be more than one-half of a pound, and would probably be less; the restriction which I have spoken of being caused by, or resulting from, the fact that the valve did not probably rise more than about three-sixteenths of an inch from its seat, which would leave a very small area of opening through which the steam had to be forced when such area is compared with the area of the pipe which conducted the steam to the valve.

Cross-int. 89. What, in your judgment, would be the amount of the lifting power of the impact of the steam against the curved lip of the valve, caused by its momentum as it issued from the ground-joint during the blowing of said valve, after it had "popped" or suddenly risen as aforesaid?

Ans. In answering this question I shall have to be governed entirely by my own judgment, and by observations which I have made upon steam issuing from an orifice. It is a fact which I presume will not be disputed that within any pipe or conduit which leads from a generator to the atmosphere the pressure will be equal to that in the generator minus what it loses by expansion and friction on the pipe; and so in

order to ascertain what the impact of the steam would be at the end of such pipe it would be necessary to know the pressure at that point, and the volume also. It is well known that when steam issues from the end of a pipe into the atmosphere it soon loses its force because of the opportunity presented for its sudden expansion, and because of the cooling effect of the atmosphere. In valves like those under consideration the distance travelled by the steam after it leaves the ground-joint and before it impinges against the curved lip of the valve is very short, and very little room is allowed for it to expand in, and consequently very little of the impinging effect is destroyed before it reaches that point; so that in my judgment a considerable force is exerted upon the valve to raise it from its seat by this impinging action of the
184 steam. To undertake to state this force in pounds pressure is a difficult matter, and I do not know of any treatise upon the steam-engine, or of any experiments which have been tried, by which I could ascertain what such pressure would be; my judgment, however, is that with a pressure of one hundred pounds in the generator this impinging action of the steam would amount to a force of from three to five pounds to the square inch; and at sixty pounds in the generator to about four pounds per square inch upon the curved lip of the valve, or upon that portion of the valve against which it impinges.

Cross-int. 90. What amount of atmospheric pressure, if any, would be taken off from the valve while blowing under the circumstances enquired about?

Ans. It is impossible for me to tell, as it is impossible to say what approach there was towards a vacuum caused by the amount of steam passing upwards around the valve; but in this case I suppose it to have been very small compared with what it would have been if there had been a pipe surrounding the valve and extending upwards for any considerable distance; the ratio of relief afforded under any circumstances would be just equal to the reduction of the pressure upon the upper surface of the valve.

Cross-int. 91. Can you give no estimate?

Ans. I cannot under the circumstances.

Cross-int. 92. Would it be appreciable?

Ans. I think it would.

Cross-int. 93. Would it amount to a pound to the square inch of the surface of the valve?

Ans. I should doubt whether it would.

Cross-int. 94. Would it amount to a half pound to the square inch of the surface of the valve?

Ans. I have already stated that I could not tell what it would amount to; and cannot, therefore, say whether it would be more or less than half a pound.

Cross-int. 95. Have you, from observation and experience, no opinion whatever upon the subject of the amount?

Ans. None, except such as I have expressed.

(Adjourned until Thursday, February 27, 10 a. m.)

185 THURSDAY, *February* 27—10 a. m.

Cross int. 96. What would be the amount of increased relief per square inch from atmospheric pressure, if all the steam were turned up, instead of a portion?

Ans. I do not know, nor can I form any opinion which I should be willing to give as an approximation to the amount. I am inclined to the opinon that it would be something more when all the steam was

thus directed upwards; and I am strengthened in this view of the case by the results of an experiment made with a Richardson valve, so called. This valve, when constructed like Exhibit 2, with the upwardly projecting flange outside of the recess or chamber around the curved lip of the valve, and when the valve was set to blow slightly at 60 lbs. pressure to the square inch, rose suddenly at a pressure of 63½ lbs.; the same valve was then taken to a machine-shop, and had its outer upwardly projecting lip, or flange, turned off so as to give it the appearance it now presents, when it was again tried in connection with the same gauge, and set to blow slightly at 60 lbs., but the pressure upon this trial rose to 67 lbs., as indicated by the gauge, before the valve "popped," or suddenly rose; and I am of the opinion that a considerable portion of this difference was due to the fact that in the last referred to trial, the steam was deflected outwards in nearly a horizontal direction, while in the first instance it was directed upwards around the valve by the outside flange above referred to.

Cross-int. 97. The difference in rising seems to have been four pounds; how much of that, in your judgment, is due to the relief of atmospheric pressure caused by the steam being turned upwards?

Ans. I have already stated, in answers to previous questions, that I could not determine, by any method known to myself, the amount of relief afforded by the ascending current of steam; but the experiment referred to in my last answer satisfies me that there must be some advantage resulting from this ascending volume of steam, which advantage is to me an unknown quantity.

Cross-int. 98. Cannot you give us your best judgment?

Ans. Since answering interrogatories 93 to 95 inclusive, I have
186 reflected upon the subject, and the best judgment which I am now able to give, which I do not undertake to say is correct, but which, in the language of the question, is my best judgment, is that, in the Naylor valve or a valve like Exhibit 3, the amount of relief afforded would be from one to two pounds per square inch, and in the valve, the flange of which had been turned off, it might reach two and a half to three pounds per square inch before said flange had been removed; these qualities, however, may be too much or too little.

Cross-int. 99. Have you a memorandum of this experiment? If yes, please examine it and see if you have got your figures right in your answer to interrogatory 96.

Ans. I have no memorandum, but believe the results of the two experiments are correctly stated.

Cross-int. 100. How did you set the valve to blow slightly at 60 lbs.? What means did you employ for that purpose?

Ans. The valve was placed upon the steam-pipe, and the steam in the generator was allowed to fall below a pressure of 60 lbs., and then caused to increase until the gauge indicated 60 lbs. pressure; the nuts upon the upper ends of the studs were then turned to the proper position to allow the valve to rise sufficiently to admit of the passage of a small quantity of steam, which quantity was just sufficient to demonstrate the fact that the valve was not in actual contact with its seat; the same plan was pursued with reference to all the other experiments of which I have spoken.

Cross-int. 101. If a certain pressure is used to compress the springs used in trying said experiments one-sixteenth of an inch, would not an additional pressure of the same amount compress the springs another one-sixteenth of an inch?

Ans. I think it would, and it would probably compress it something more.

Cross-int. 102. Why something more?

Ans. Because of the fact that a certain amount of pressure has to be expended in putting the particles of the steel of which the spring is composed in motion; when once such motion has been commenced it can be carried through double the space without doubling the force exerted upon it.

187 Cross-int. 103. After the steel has been put in motion, will the length of the compression register correctly the additional pressure brought to bear upon the spring?

Ans. In the experiments tried, a compression of the spring has had nothing to do with the registering of the pressure.

Cross-int. 104. Are you not aware that there are springs used in scales used by provision-dealers and others, for the purpose of weighing articles?

Ans. I am; and it is my firm opinion that they sometimes give false weights.

Cross-int. 105. Which give false weights—the provision-dealers or the springs?

Ans. I refer more particularly to the provision-dealers.

Cross-int. 106. When you have a spring like these used in the experiments, of a given strength, cannot you ascertain the amount of pressure brought to bear upon it by the length of its compression?

Ans. You can, by making an experiment; but I know of no means of doing it without such experiments.

Cross-int. 107. After said springs have been compressed somewhat, would not every additional pressure of a like amount compress the spring a like distance?

Ans. I have already answered that question, or one involving the same idea, as correctly as I can.

Cross-int. 108. Suppose a spring like those used in the experiments, to be compressed somewhat; and then suppose a pressure of fifty pounds placed upon it to compress it one thirty-second of an inch, and the spring then permitted to be at rest, would not the placing of another pressure of fifty pounds upon it compress it an additional one thirty-second of an inch?

Ans. In my judgment it would not.

Cross-int. 109. Why not?

Ans. For the reason that, as the space between the coils of the spring are diminished, or in other words, the nearer the form of a perfect ring the coils of the spring assume, the greater the resistance is, offered by such coils.

188 Cross-int. 110. Is that increased resistance considerable, or inconsiderable, during all periods of its compression?

Ans. In a spring of the character of those used in the experiments it would be less when the compression first began than it would under a greater compression; and could, I think, in its average, be regarded as considerable.

Cross-int. 111. You have spoken of experiments made upon a Richardson valve with the cup used to turn the steam up, turned off; is that the valve marked "Exhibit 5?"

Ans. It is the one which has just been marked as described in the question.

Cross-int. 112. Are Exhibits 3 and 4 alike in construction and mode of operation?

Ans. They are substantially alike in construction, there being, I believe, a slight difference in the width of the space between the over hanging lip of the outer casing of the valve; another slight difference which I have observed is, that the upper surfaces of the valves do not sustain precisely the same relation in reference to the upper surface of the casing; but neither of these differences would, in my judgment, affect the mode of operation of the two valves.

Cross-int. 113. In which is the space between the overhanging lip and the outer casing the larger?

Ans. It is slightly the largest in Exhibit 3.

Cross-int. 114. Are those all of the differences you have noticed?

Ans. They are, with the exception that the passages for the steam through the diaphragm, or stricture, at the lower end of chamber D, are a little larger in Exhibit 4 than those in Exhibit 3.

Cross-int. 115. What is the difference in the size of those passages in the diaphragms?

Ans. Those in Exhibit 4 appear to be one-half of an inch in diameter, while those in Exhibit 3 appear to be three-eighths of an inch; having measured them as nearly as I can, I find that they are both about one sixty-fourth of an inch less, or a trifle more, than the diameters above given.

189 Cross-int. 116. Do you know why one of the holes originally cut in Exhibit 3 was closed?

Ans. I do not.

Cross-int. 117. Suppose the space between the outer lip of the valve and the valve-casing, added to the aggregate openings in the diaphragm in Exhibit 3, would the amount of said outlets be larger or smaller than the amount of the corresponding space and openings in Exhibit 4?

Ans. I should say that there would be very little difference; but if there were any, the largest aggregate space would be found in Exhibit 4.

Cross-int. 118. What effect would that difference have upon the pressure of the steam under the lip of the valve in Exhibit 3, when the same was blowing after it had "popped," or risen suddenly? Would it be greater or smaller than if the aggregate amount of the openings were as great as in Exhibit 4?

Ans. I do not suppose there would be any perceptible difference in the two cases.

Cross-int. 119. Is not the pressure under the lip of the valve caused by the confinement of the steam in the space between it and the diaphragm?

Ans. It is not; because the steam is not thus confined.

Cross-int. 120. Is not said pressure affected by the obstructions offered to its escape by the lip of the valve, the valve-casing, and the diaphragm?

Ans. It is, to some extent; but the pressure would be affected to the same extent if the diaphragm was entirely removed and the same amount of obstruction to the passage of the steam was placed at any other point within or upon the chamber, so as to act upon the steam before it passed into the atmosphere.

Cross-int. 121. The question is not what might be under another state of circumstances, but is, whether said pressure is not caused by the obstruction offered to the escape of the steam by the lip of the valve, the valve-casing, and the diaphragm?

Ans. Such pressure is, I believe, caused by the obstruction offered to its escape by the lip of the valve, the casing, the diaphragm,

190 and the bottom of the chamber into which the steam is directed

by the lip of the valve; and I find that in the English specification describing this same invention, that the inventor speaks of deflecting the steam downwards by the curved lip of the valve, so that it "strikes against the bottom of a suitable recess, or into a chamber round the pipe leading from the boiler to the valve, and consequently the recoiling action of the steam acts upward against the under surface of the valve, as it issues forth into the atmosphere, and by such recoiling action of the steam, the valve is assisted in opening." Finding this language in the English specification, describing, as I believe, the identical invention described and claimed in the reissued patents on which this suit is brought, and considering the state of the art in connection therewith at the time said English patent was granted, this inventor being the first, as I understand it, to combine or use in connection in a safety-valve a suitable recess or chamber, and a valve with a curved lip for the purpose of obtaining a recoiling action of the steam against the under side of said lip, he is, in my judgment, at liberty to use any mechanism for that purpose, which is not in its effect substantially different from what he has described, or which does not produce the same effect in a better manner. Holding as I do to this view of the case, I do not believe that a person constructing valves under that patent or under the reissued patent upon which this suit is brought, is limited to any particular form of device for producing this static pressure, as it has been termed, or as the inventor terms it, recoiling action of the steam; but, as before stated, that he is at liberty to use any form of obstruction to the passage of the steam to the atmosphere, whether it be a diaphragm with apertures through it, radial bars extending across the passage between the pipe which conducts the steam to the valve, or a nozzle upon the outside of the casing of the proper dimensions to produce the result which the inventor says should be produced in constructing a valve in accordance with his invention. It is this view of the case which has induced me to describe the valves Exhibits 3 and 4, as being substantially the same in their modes of operation as that described in the patent referred to, notwithstanding the admitted unimportant change in the mechanical structure of the valves; and
191 it was this view also which led me to state that the slight difference in the aggregate apertures of the two valves was unimportant, because under either form they would be substantially as described in the patent. I stated, also, that this aggregate of apertures and spaces around the valves would not, in my judgment, make any perceptible difference in the operation of the valves, or in the pressure on the under surface of the curved lip, because it is apparent that so long as the aperture through which the steam is discharged into the recess or chamber, is greater than that through which it is discharged, a sufficient pressure will be maintained within said recess or chamber to produce the effect described by the inventor.

Cross-int. 122. I wish to know, irrespective of your view of the case, as you consider it stated in the patent, specifically whether there is anything which, when Exhibit 3 is blowing, causes the pressure underneath the lip of the valve, except the lip of the valve, the valve-casing, the diaphragm and whatever pressure may exist, if any, to the escape of the steam in the chamber under the diaphragm?

Ans. In my opinion there is another agent which performs an important part of the effect named in the question, which is the steam which is issuing from the generator.

Cross-int. 123. By that do you mean the impact of the steam upon the curved lip of the valve?

A: s I do not mean its impinging force upon the valve; but I mean to say that "the lip of the valve, the valve-casing, the diaphragm, and whatever pressure may exist, if any, to the escape of the steam in the chamber under the diaphragm," would not raise the valve unless steam was furnished to fill the chamber.

Adjourned until Friday, February 28, at 10 a. m.

FRIDAY, *February* 28—10 a. m.

Cross-int. 124. Please explain a little more fully the last sentence in your answer to interrogatory 121.

Ans. I intend to say in answering that question, that so long as the area of opening at the ground joint of the valve was as large as or larger than the combined area of the openings in the diaphragm or escape
192 passages from the recess or chamber, the pressure in such recess or chamber would be sufficient to open the valve when added to the impinging force of the steam against its curved lip.

Cross-int. 125. What would be the rise of the valve which would make the area of the opening at the ground joint equal to the area of all the openings through the diaphragm and between the lip of the valve and the valve-casing, as in Exhibit 3?

Ans. I have not measured or calculated the lift of the valve necessary to make th eareas of the openings alluded to equal, and cannot therefore tell; it would not, however, be necessary that the area of the opening at the ground joint should be equal to the combined areas of the different openings referred to in the question, as a portion of the upward pressure of the steam would be exerted upon the lip of the valve, whatever the area of the opening in said lip and the casing might be. A lift of three-sixteenths of an inch, as in the case of the experiment tried, would, I think, give an area of opening equal to, and probably greater than, the combined areas of the openings in the diaphragm.

Cross-int. 126. Is there any change in the area of the escape-orifice of Exhibit 3, through the diaphragm and round the lip of the valve, in any period of the lift of the valve, or does said area remain the same as when the valve is at rest?

Ans. There is no such difference; but the areas referred to remain substantially the same when the valve is in a state of rest that they are when steam is passing out through them.

Cross-int. 127. How many experiments did you make with Exhibit 5 before the lip which turns the steam up was turned off?

Ans. I think not but one, with a view to ascertain the points at which the valve would rise suddenly and at which it would close.

Cross-int. 128. Did you make any others with it before that lip was turned off for any purpose?

Ans. I did.

Cross-int. 129. When?

Ans. On the same day that the last-named experiment (February 24th, current) was made. This experiment was made with a view of testing the pressure of steam on the under lip of the valve, which pressure I found to be twelve pounds; the indicator-point oscillating
193 between the mark indicating twelve pounds and that indicating fifteen pounds.

Cross-int. 130. Please describe particularly what you mean in this answer by the under lip of the valve.

Ans. I intended to have said the under side of the lip of the valve.

Cross-int. 131. What was the pressure in the boiler at that time?

Ans. The valve commenced blowing slightly at sixty pounds, that

being the point at which all the experiments made upon that day and upon the 21st of the same month were started; the pressure rose in the boiler to sixty-four pounds, when the valve suddenly rose, and it was while the valve was discharging the greatest amount of steam that the indicated pressure under the lip of the valve was observed.

Cross-int. 132. What was the pressure in the boiler when the valve closed?

Ans. I think that in this experiment the stop-valve in the steam-pipe was closed before the safety-valve closed automatically; it, however, was allowed to blow off steam until it was apparent by the gauge which was in communication with the lip of the valve that the pressure was being reduced in the generator; and when this fact had been observed there did not appear to be any necessity for continuing the experiment farther, as it was evident that the greatest amount of pressure which could be obtained with the pressure in the generator what it then was had been ascertained.

Cross-int. 133. Did you make any experiment to ascertain what reduction, if any, of the pressure in the boiler was made before the Richardson valve closed from that at which it started?

Ans. I did, on the same day; upon making the experiment alluded to as the first of the series with the valve Exhibit 5, it was such as I have before stated. It commenced blowing at sixty pounds, and rose suddenly at a pressure of about sixty-three pounds. In this case it was allowed to close automatically, which it did at a pressure of between fifty-eight and fifty-nine pounds.

Cross-int. 134. At the close of your answer to the 10th inter-
194 rogatory, you say that the pressure indicated by the gauge upon the generator within 30 seconds of the time the valve popped was 63 lbs.; was that before or after the valve "popped"?

Ans. I should say it was before.

Cross-int. 135. How much per minute did the pressure of the steam in the boiler increase when you were getting up steam for these experiments?

Ans. I do not know.

Cross-int. 136. What, in your judgment, was the largest increase of steam per minute during said experiments?

Ans. I have no idea what it was, for the reason that I did not observe the time in reference to such increase of pressure, and as my mind was occupied with other matters at the time I cannot undertake to give an opinion in reference to it.

Cross-int. 137. What was the size of the perpendicular pipe from the boiler to the pipes leading therefrom, about which you have testified?

Ans. Three inches in its internal diameter.

Cross-int. 138. What kind of valve was the stop-valve on the pipe leading therefrom to the valves on which the experiments were tried; was it a globe or straight valve?

Ans. It had every appearance of being what is technically termed a globe-valve.

Cross-int. 139. Is not the obstruction offered by a globe-valve, when open to the passage of steam, equal to the obstruction offered by two elbows?

Ans. In a globe-valve, properly constructed, there is no more obstruction at that point than in any other portion of the pipe.

Cross-int. 140. Does not the steam have to turn in passing a globe-valve?

Ans. In some valves which are termed globe-valves it does; in others it does not.

Cross-int. 141. Do you know which of the two kinds this was?

Ans. I do not.

Cross int. 142. Look at Exhibit Z, and state whether it does not represent the common globe-valve.

195 Ans. It does represent one form of a globe-valve, or stop-valve, as it has been termed in the preceding questions and answers; and I believe that it represents the stop-valve before mentioned in the testimony relating to the experiments, as M'r Ashcroft, who is now present, so states.

Cross-int. 143. What is the area of the valve in each of said Exhibits 3, 4, and 5, inside the ground joint; and what is the area of each of said valves outside of the inner line of the ground joint within the lip?

Ans. The area of each of the valves inside the ground joint, is 3,976 inches, in which respect they are all alike, being two and a quarter inches in diameter; the valve Exhibit 5 has an area outside of the ground joint and within the lip, of 4,319 square inches, being the area of the annulus outside the ground joint, and within the lip of the valve, the inner diameter of this annulus being two and a quarter inches, and the outer diameter about three and five-sixteenths inches; Exhibit 4 has the same area within the ground joint as Exhibit 5, and an area outside and within the curved lip of the valve of 7,817 square inches, being the area of the annulus outside of the ground joint, and within the lip of the valve, the inner diameter of this annulus being two and a quarter inches, and the outer diameter three and seven-eighths inches, while the valve Exhibit 3, has an area outside the ground joint of 7,068 square inches, being the area of the annulus outside of the ground joint, and within the lip of the valve, the inner diameter of this annulus being two and a quarter inches, the outer being about three and three-quarter inches.

Cross-int. 144. Can you now give the area of the openings in the diaphragms and between the outside of the valves and the inside of the valve-casings in Exhibits 3 and 4?

Ans. I can; the area of the openings through the diaphragm, or the bottom of the recess in Exhibit 4, is 1,374, calling each one half of an inch in diameter, although they are in reality slightly less; the area of the opening between the outer edge of the lip of the valve and the casing is twelve-sixteenths of a square inch, it being an annulus one-sixteenth of an inch in width, and four inches in diameter; the area

196 of the holes, or apertures through the diaphragm in Exhibit 3, are .77315 of a square inch, while the area of the aperture between the outer edge of the lip of the valve and the valve-casing, is substantially the same as that given for Exhibit 4, or twelve-sixteenths of an inch.

Cross-int. 145. What is the area of each of the openings in Exhibits 3 and 4 at what is called the nozzle, opening from the chamber into the atmosphere?

Ans. The area of each is 2.4052 square inches.

(Adjourned to Saturday, March 1, at 10 a. m.)

SATURDAY, *March* 1, 1873.

Cross-int. 146 What is the area of the opening at the ground joint, in Exhibits 3 and 4, when the valve is lifted three-sixteenths of an inch?

Ans. It would be substantially twenty-one sixteenths of an inch, or one inch and five-sixteenths.

Cross-int. 147. What lift of the valve in each of Exhibits 3 and 4 would make the area of the openings at the ground joint equal to the aggregate areas of the holes in the diaphragm, and the orifices between the lips of the valves and the valve-casings?

Ans. In Exhibit 4 it would be one-fourth of an inch, in Exhibit 3 it would be a fraction less than three-sixteenths of an inch.

Cross-int. 148. Is not the effect of the globe-valve on the pipe testified about, in obstructing the flow of the steam, equal to two elbows?

Ans. I should think not; as it only causes a right-angular turn in the steam I cannot see why it should be equal to more than one, if it were admitted that it obstructed the passage of the steam at all, which, when used, as in the case of the experiments referred to, it does not do.

Cross-int. 149. In your answer to interrogatory 133, you state, alluding to Exhibit 5, that it commenced blowing at sixty pounds and rose suddenly to a pressure of about sixty-three pounds, and that it closed automatically at a pressure of between fifty-eight and fifty-nine pounds; what was there in said valve which so reduced the steam before it closed?

197 Ans. I suppose the reason to be the pressure of the steam in the boiler and its impinging force against the under side of the lip of the valve, and the fact that the steam has to be more or less compressed in the recess in the under side of the valve before it can be returned to its seat.

Cross-int. 150. What do you call the two forces outside the ground joint which keep the valve opened until the pressure in the boiler is relieved below the point at which the valve started to blow?

Ans. I call one the pressure of steam, and the other a partial vacuum or a removal of a portion of the atmospheric pressure from the upper surface of the valve.

Cross-int. 151. Is not what you have said in your last answer, regarding the atmospheric pressure, an addition to the reasons given in the next previous answer?

Ans. I do not see that it is.

Cross-int. 152. Under which of the three reasons given in your answer to interrogatory 149 do you place the removal of a portion of the atmospheric pressure from the upper surface of the valve?

Ans. Neither of them.

Cross-int. 153. Does not the common safety-valve close at the pressure at which it rises?

Ans. It does not, generally.

Cross-int. 154. Does it close at a point above or below that at which it rises?

Ans. Generally below.

Cross-int. 155. How much below, generally?

Ans. I cannot tell; it varies according to the pressure in the generator.

Cross-int. 156. How does that vary it?

Ans. By its resistance to the closing motion of the valve.

Cross-int. 157. How, in the common safety-valve, is that resistance greater or less than the power which raises it?

Ans. In the common safety-valve, when it is raised, the momentum of the steam when it has been raised causes an amount of force due to such steam, which steam in a state of rest does not have.

Cross-int. 158. Can you give no idea of the effect of that momen-

198 tum upon the point at which the common safety-valve closes, compared with that at which it rises?

Ans. I can; its momentum is less, owing to the fact that the pressure in the generator has been reduced, and its effect is to allow the valves to close.

Cross-int. 159. When a common safety-valve rises at a pressure in the boiler of one hundred pounds, what is the usual pressure in the boiler when it closes?

Ans. I do not know.

Cross-int. 160. Can you give no opinion as to it?

Ans. I cannot give any opinion that in my own judgment would be of any value, as I do not suppose that any two safety-valves, such as are termed in the question common safety-valves, would close at the same reduction of pressure; and such reduction would, I presume, vary from one to ten pounds.

Cross-int. 161. What do you understand by the common safety-valve?

Ans. I understand it to mean a disc of metal, sometimes bevelled upon its under side to fit its seat, while others have a flat surface, or a surface at right angles to the line of the axis of the valve-spindle; which valves are usually held down by a lever and a weight, the short arm of the lever being attached to a stud in the casing of the valve.

Cross-int. 162. Confining your answer now to the common safety-valve, bevelled like the ground joint in Exhibit L, to what extent do they vary at their point of closing when set to rise at a pressure of one hundred pounds?

Ans. So far as my observation has extended, they vary within the limits previously given.

Cross-int. 163. To what is that variation due?

Ans. To the construction of the valve or the parts which hold it in position; and to the varying pressures in the generators to which they are attached.

Cross-int. 164. The question supposes the pressure in the generators to be the same at the point of starting, and the valves to close automatically when the amount of pressure will permit them; what,

199 if any, is the difference in the closing under such circumstances of the common safety-valves with the bevelled edge described, and what is the cause of such difference?

Ans. The difference in their closing I have already stated as nearly as I can. The causes of such variations are numerous; one cause is the friction of the parts, which varies more or less in a large majority of the common safety-valves in use; another cause may be the compression of the steam which takes place while the valve is closing, some of such valves being exposed to the atmosphere, so that the steam when it has escaped from the ground-joint may pass off freely; others being placed in pipes which are used for conducting away the steam from the valve, in which case the surrounding steam has to be to some extent compressed by the closing of the valve.

Cross-int. 165. The object of the enquiry is not as to the effect of the varied circumstances in which the valves may be placed; but as to the operation of common safety-valves constructed with an ordinary bevelled edge or ground-joint, the valves being of the same size, on generators of like power, set to rise at a given pressure, say one hundred pounds, and with the outward surroundings the same, is there practically anything to interfere with their closing at the same point, except what may be due to the friction of the parts?

Ans. There is; the compression of the steam which I have before

spoken of, it being a fact that nearly all of the escaping steam which is underneath the valve at the time of closing has to be arrested in its passage from the boiler, and a portion of it, however small it may be, forced back into the generator; which action cannot be performed without the employment of a force greater than that of the steam itself, and consequently before the valve can close the pressure in the generator must be reduced until there is a preponderance of power in the weight and lever before referred to, with the weight of the valve added thereto.

Cross-int. 166. Please answer that part of the previous question which asks whether there is, practically, anything to interfere with the valves enquired about, closing at the same point of pressure, except what may be due to a friction of the parts.

200 Ans. My last answer was intended to practically answer that question; and I will now state that the reasons therein given, are, in my judgment, such as to practically interfere with the closing of the valve.

Cross-int. 167. What is there in that answer which gives any reason why the valves enquired about should not close at the same pressure, except what may be due to the friction of the parts?

Ans. The fact that any body when in motion in a given direction cannot have that motion arrested, and be turned back against the force which put it in motion, without the expenditure of a force greater than that which first put the body in motion; this is true of steam and other gases, as well as of solids.

Cross-int. 168. Do you not understand the question to be upon the effect of steam upon different valves of like construction, similarly situated, the steam being of the same pressure with regard to each valve, when set to rise, and rising at the same pressure, and permitted to close automatically by the reduction of that pressure?

Ans. I do; and my answers have been framed with reference to that understanding, and not with reference to the action of any one valve while upon a generator; and I have not stated that any one valve would show this difference in the pressure between the point of opening and closing.

Cross-int. 169. Do the reasons which you have given apply to all safety-valves, of every description?

Ans. Some of them do; but to a much greater extent in some valves than in others.

Cross-int. 170. Suppose two common safety-valves of the same size, with bevelled edge or ground-joint, and of like construction, as near as mechanics can usually make them, placed upon the same generator, set to rise, and rising at the same pressure, say one hundred pounds per square inch, what is there to prevent their closing at the same point of pressure, except some possible difference in the friction of the parts?

Ans. The force which I have already two or three times described.

Cross-int. 171. How can that force differ in its action upon the two valves?

201 Ans. It does not differ.

Cross-int. 172. Why, then, should they not close at the same point of pressure?

Ans. Under the circumstances described I have no doubt that they would close at the same point of pressure in the generator, but that would be a point below that at which they rose.

Cross-int. 173. How much?

Ans. It is impossible for me to tell, or even to approximate to it, without being able to understand all the circumstances surrounding them.

Cross-int. 174. What is the defect in the common safety-valves sought to be remedied by the inventions in dispute between the parties?

Ans. In the common safety-valve when rising the usual distance from its seat, the aperture caused by such rising is frequently too small to admit of the escape of the steam from the generator with the same rapidity with which it is formed therein; as a consequence of which, a pressure greater than that at which the valve is set, frequently obtains within said generator, and this increase of pressure, unless there is a steam-gauge which can be referred to, cannot be determined. The inventions in dispute, I understand to be intended to remedy this defect.

(Adjourned to Monday, March 3, at 10 a. m.)

MONDAY, *March* 3—10 a. m.

Cross-int. 175. What, in your opinion, would be the effect upon the issue of steam from Exhibit G, if the projecting lip of the valve was flat and horizontal, instead of being curved downward, as it is in said exhibit, the space between the edge of the lip and the valve-casing being the same as in said exhibit?

(Objected to as immaterial, &c.)

Ans. I suppose it would have the effect to cause a little more steam to pass out around said lip, when the steam first entered the chamber; as in that event the steam would not be directed downwards with the same force that it is by the curved lip.

202 Cross-int. 176. Would not the steam in that case strike against the valve-casing, directly opposite the lower side of the lip of the valve, and a portion of it, to the extent of the opening between the lip and the valve-casing, be turned upwards, and the other part downwards into the recess or chamber?

(Same objection.)

Ans. It would strike against the casing, as stated in the question, and a portion of it would pass up around the lip of the valve, while another portion would pass down into the chamber below said lip.

Cross-int. 177. To what force or forces would the passing of the steam up between the lip and the valve-casing be due?

(Same objection.)

Ans. It would be due to the expansive force of the steam.

Cross-int. 178. Would not the impinging force of the steam, as it strikes at right angles to the perpendicular walls of the valve-casing, give an additional tendency to the steam's going up past the lip as well as down into the recess?

(Same objection.)

Ans. I do not see that the impinging force of the steam would have any effect to turn it in either direction, as what I understand to be such force would be expended upon the wall of the valve-chamber.

Cross-int. 179. Do you make any distinction in your testimony between the words "recess" and "chamber?"

Ans. I do. I make just the distinction that I understand to be made in the patent describing this invention.

Cross-int. 180. In which of the exhibits do you find "recess," and in which "chambers?"

Ans. I find a "recess" in Exhibit 2 and in Exhibit L; and in Exhibits 3 and 4 a "recess" and "chamber" united. I also find that Exhibit 5 formerly had a recess surrounding the lip of the valve, but that the

o ıter flange of said recess has been turned off. In Exhibit G I find what I denominate a "chamber."

Cross-int. 181. What parts are the "chambers," and what parts "recesses," in Exhibits 3 and 4?

203 Ans. According to the distinction I have made, the parts above the diaphragm are regarded as "recesses," and the parts below as "chambers."

Cross-int. 182. Do you mean to give it as your opinion that the dynamic force of the steam in striking at right angles to the walls of the valve-casing in Exhibit G, would have no effect upon the amount of steam, suppose the lip of the valve to be flat and horizontal, which would issue between the lip and the valve-casing?

(Same objection.)

Ans. I do not; and have not so stated.

Cross-int. 183. Would it have any; and, if yes, what?

(Same objection.)

Ans. It would have the effect to send the steam against the wall of the chamber, when its impinging force would be expended; and in meeting with such resistance the steam would pass off upon the line of least resistance to its motion.

Cross-int. 184. Would not the effect be to scatter the steam at right angles from the direction it had before it strikes the walls of the valve-casing?

(Same objection.)

Ans. I have already stated that the steam would pass off from the point where it impinges against the wall of the chamber; and if the resistance to its further movements was equal at both right angles, it would, I think, have such a tendency; but if the pressure or resistance to its movement was greater above such point of contact than below, it would be directed downwards; as, for instance, suppose a diaphragm to be placed immediately above the point where the steam strikes the wall, and such diaphragm to be immovable, it is apparent that all the steam would be turned downwards, because that in that direction the line of least resistance to its movements would be found, and this would be found to be the case if the diaphragm were made movable, so long as its weight was greater than whatever force the steam, acting upon its under surface, was able to overcome.

Cross-int. 185. The question is not as to how that force could be
204 overcome, but as to the tendency of that force; would not the dynamic force have a tendency to scatter the steam directly from the point of its impingement against the walls?

(Same objection.)

Ans. I think it would.

Cross-int. 186. Suppose the projecting lip of the valve from the ground joint to its outer periphery were bevelled upwards in Exhibit G, would more or less steam pass out between the lip of the valve and the valve-casing than if said lip were flat and horizontal, as enquired about?

(Same objection.)

Ans. With the size of the aperture between the lip of the valve and the casing, the same as in the before-supposed case, there would be no perceptible difference.

Cross-int. 187. Suppose the lip from the ground joint to its outer periphery in Exhibit G, to be continued to its outer periphery in an exact line with the ground joint, and the aperture to remain the same as before enquired about, would any more or less steam pass out than would if the lip were flat and horizontal?

(Same objection.)

Ans. With the same pressure underneath the lip of the valve in both of the supposed cases, there would not be any perceptible difference in the amount of steam discharged around the lip of the valve.

Cross-int. 188. Would not the dynamic force of the steam have a more direct tendency to force the steam up around the lip of the valve, in the case last enquired about, than it would if the lip were horizontal?

(Same objection.)

Ans. It would not, but, on the contrary, it would, in my judgment, have a less effect, because of the fact that it would have farther to travel before reaching the point of exit, and a considerably larger space in which to expand.

Cross-int. 189. Would not that loss of force due to the increased distance of travel and room for expansion be more than overcome by the direction of the steam against the aperture?

(Same objection.)

205 Ans. In my judgment it would not.

Cross-int. 190. Please examine the drawings in the reissued patent, Exhibit 1, and then state the diameter of the opening inside the walls of the valve-casing in Figure 1; and also the diameter of exit-passage B, as the same appear in the said drawings.

Ans. The diameter of the opening at the upper end of the casing is one and seven-eighth inches; the diameter of the opening at the nozzle B is one and three quarters inches and a sixteenth more.

Cross-int. 191. What is the size of the representation of the opening in the nozzle B on Figure 2 of said drawing?

Ans. It is the same as in Figure 1, substantially.

Cross-int. 192. Please look at the drawings, sheet 1, Defendant's Exhibit C, and state the diameter inside the valve-casings of Figure 1 in said Exhibit; and also the inside diameter of nozzle, or exist-pipe B in said figure.

Ans. The diameter of the inside of the casing is a sixty-fourth more than one and seven-eighth inches, while the diameter of nozzle B is one-sixteenth more than one and three-fourths inches.

Cross-int. 193. In how many instances in said sheet is the nozzle, or exit-pipe B represented?

Ans. In five instances.

Cross-int. 194. In how many instances is the inside diameter of said exit pipe represented?

Ans. Four.

Cross-int. 195. Is not said diameter the same in all those instances?

Ans. It is, very nearly, the lines showing them varying to the extent of about one sixty-fourth part of an inch; it is not probable, however, that this variation in lines was intended to be any guide to the constructor of the valve, as the diameter of said opening or nozzle is a matter left entirely to his discretion and to the instructions given in the specification.

Cross-int. 196. What is the diameter inside the valve-casings, and what inside the nozzles or exit-pipes, in Exhibits 3 and 4?

Ans. The diameter of the opening in Exhibit 3 in the valve-casing is four inches and one-sixteenth of an inch, while the diame-

206 ter of the nozzle B is one and three-fourths inches, and they are the same in Exhibit 4.

Cross-int. 197. What is the excess of the area inside the valve-casings of each of said Exhibits 3 and 4, over the area of each of the nozzles?

Ans. It is about ten and a half square inches.

Cross-int. 198. What is the entire area inside the valve-casings in Exhibits 3 and 4?

Ans. About twelve and three-fourths inches.

Cross-int. 199. What do you now make the area inside the nozzle B?

Ans. I make it 2.4052 inches.

Cross-int. 200. You find, do you not, that in the drawings in said Exhibits the areas of the nozzles or exit-pipes B and of the space inside the valve-casings are substantially alike, differing but one-sixteenth of an inch in diameter, while in Exhibits 3 and 4 the areas of the openings are each about six times the areas of the nozzles or exit-pipes?

Ans. Yes, I do.

Cross-int. 201. So far, then, as the relative sizes of said openings are concerned, Exhibits 3 and 4 are not like the drawings in Exhibits 1 and C, are they?

Ans. They are not.

Cross-int. 202. What is the diameter inside the ground joint in Exhibits 1 and C, and what is the diameter under the ground joint of Exhibits 3 and 4?

Ans. In Exhibits 1 and C, it is one inch, and in Exhibits 3 and 4 it is two and a quarter inches.

Cross-int. 203. So that in Exhibits 1 and C, the nozzle or exit-pipe B has three-fourths of an inch and one sixteenth greater diameter than the inside of the ground joints in said Exhibits, while in Exhibits 3 and 4 the diameter of the nozzles or exit-pipes B are a half an inch less than the diameters inside the ground joint; is not that the case?

Ans. It is.

Cross-int. 204. In that respect, then, said Exhibits 3 and 4 are unlike said drawings, are they not?

207 Ans. They are.

Cross-int. 205. Do you find in said drawings, in Exhibits 1 and C, any representation of any such diaphragm as is found in Exhibits 3 and 4?

Ans. I do find in Exhibit 1 what appears to be, and in my judgment is, a representation of a diaphragm with apertures formed in it; and with my knowledge of drawings, if I were instructed to make a valve in accordance with figure 1 of Exhibit 1, I should place therein a diaphragm having at least two such apertures through it, and as many more as I should regard as necessary to make it operate according to the instructions given in the specifications; the figure referred to showing only two such apertures, which might or might not be sufficient to direct the proper proportion of the steam upwards, and the proper portion downwards. In Exhibit C I find what appears to be partitions extending across the passage between the inner side of the valve-casing and the outer side of the conduit which directs the steam to the valve, the openings for the passage of the steam downwards being between such partitions. These partitions, if made of the requisite size, would serve the same purpose as the diaphragm does with the apertures through it.

Cross-int. 206. Do you find anything in the drawings to Exhibit C which indicates the size in said exhibit of what you term partitions?

Ans. I do not. I do find, however, that in said figure the upper surface of the partitions is considerably less than the size of the apertures through which the steam passes downwards; but I do not regard this as in any sense limiting the size which may be given to such partitions. The figure referred to is made to represent a valve constructed to operate upon the principle described in the specification, and there is

no pretence that it professes to give in any one particular the dimensions of any one part of such valve; there being no indication in said figure, or in any other part of the drawings, that they are made to any scale.

Cross-int. 207. What is the number and what is the thickness of said partitions, as they appear in said drawing? Please confine your answer to the question.

208 Ans. The number is four, the thickness of each being one-eighth of an inch.

Cross-int. 208. What is their greatest direct distance apart, and what their shortest, and are they equidistant from each other?

Ans. Their greatest direct distance is a fraction more than one and one-eighth inches, their shortest distance being about seven-eighths of an inch; they are equidistant from each other.

Cross-int. 209. So that by said drawings in Exhibit C, said partitions appear to occupy one-half of an inch of the space between the steam pipe or conduit and the valve-casing; is not that so?

Ans. It is.

Cross-int. 210. Please point out what in Exhibit 1 represents the two apertures which you say you find in the partitions or diaphragm?

Ans. The dotted lines drawn vertically through that portion which I regard as a diaphragm; and the further fact that the wall of the conduit for the steam to pass through to the valve, as well as the wall of the casing of the valve, is represented as being thicker at that point than at any other; this representation could not properly be made if this drawing was intended to represent a partition, such as I have before referred to, across the space between the steam-conduit and the casing of the valve.

Cross-int. 211. Is there anything else in said drawing itself to indicate that the lines passing between said dotted lines, and across the space between the steam-pipe and the valve casing, are more than partitions or feathers to hold together the steam-pipe and valve-casing?

Ans. I do not see that there is.

Cross-int. 212. Confining yourself to said drawings, are said Exhibits 3 and 4 like the valves represented in said drawings in Exhibits 1 and C?

Ans. In principle and mode of operation they are like them, but with reference to some of the mechanical features they are dissimilar.

Cross-int. 213. Suppose a valve constructed in accordance with the measurements of the various parts as appear in said drawings,

209 and what have been termed partitions, only four in number, and one-eighth of an inch in diameter, and the rest of the space between the steam-pipe and the valve-casing entirely open to the exit-pipe B and the bottom of the chamber, there being no increased thickness of the walls of said steam-pipe and valve-casing, excepting only in the particular parts where the partitions or feathers are attached, would any of the steam, when the valve is blowing, after the valve has popped or opened suddenly at a considerable pressure, pass upward between the lip of the valve and the valve-casing?

Ans. I am confident that it would.

Cross-int. 214. What is the diameter of the inside of the valve-casing in Exhibit G; what the diameter inside the ground joint; what the diameter inside the nozzle or exit-pipe B; what the diameters or thickness of the partitions or feathers; what the depth of the chamber in Exhibit G, and what the distance between the steam-pipe and the valve-casing?

(Adjourned until Tuesday, March 4, at 10 a. m.)

Ans. The diameter of the inside of the valve-casing is four and one-eighth inches; the diameter inside the ground joint is two and one-fourth inches; the diameter inside the nozzle or exit-pipe B is four inches, full, inside of the pipe, which is screwed into said nozzle; the thickness of the partitions or feathers is one-fourth of an inch; the depth of the chamber is seven inches; the distance between the steam-pipe and valve-casing is three-fourths of an inch.

Cross-int. 215. What is the depth of the chambers, and what the distance between the walls in the drawings in Exhibits 1 and C?

Ans. The depth of the recess and chambers in the exhibits referred to in the question are three and one-half inches; the distance between the walls of the steam-pipe and valve-casing is a fraction more than five-sixteenths of an inch.

Cross-int. 216. Are not the dotted lines in figure 1 of complainant's Exhibit 1 used for the purpose of showing that there is an open space beyond?

Ans. I do not think they can be; because if they were intended
210 for such a purpose, it would be an entire departure from the usual method of making drawings; and for the further reason that if in this particular instance they were intended for any such purpose they should be on a line with the interior surface of the recess, and the outer surface of the steam-conduit. In no other way could they represent the space beyond, if it were admitted that they were intended for that purpose, which is not admitted.

Cross-int. 217. What is the usual purpose of dotted lines in section drawings?

Ans. It is to show that there is some part of the substance of which the device which is being represented is made that is hidden from view, and to show passages through the substance.

Cross-int. 218. To show passages through the substance which is in view?

Ans. Yes.

Cross-int. 219. If, then, the dotted lines in figure 1 were in a line with the lines of the inner side of the valve-casing and the outer line of the steam-pipe, they would be a proper means of showing that the space was open beyond, would they not?

Ans. They would not.

Cross-int. 220. Are they not frequently used for that purpose?

Ans. I have never seen them so used.

Cross-int. 221. How do you reconcile your last two answers with your next previous answer?

Ans. I do not see that there is any conflict in said answers.

Cross-int. 222. Suppose the black lines extending in figure 1 of said Exhibit 1 from the valve-casing to the steam-pipe, and across chamber D, were intended to represent partitions or radial bars or feathers, would not dotted lines placed on a line with the walls of said valve-casing and steam-pipe be a proper means whereby to indicate such intention?

Ans. They would not.

Cross-int. 223. What means would you employ for that purpose?

Ans. A sectional drawing through the partitions or radial bar, or at some other point, where a view of such bars or partitions could be had without being obstructed.

211 Cross-int. 224. Do you mean such sectional drawings as are found in figures 2 and 6, on the first sheet, Exhibit C?

Ans. Not necessarily, such drawings as those, because in them there are many features shown not necessary in giving a view of the partitions or bars; but I mean, as stated in my last answer, such a sectional view as would show said bars.

Cross-int. 225. Are not figures 2 and 6 in said drawing, Exhibit C, sectional views which do represent such bars or feathers?

Ans. They are.

Cross-int. 226. Are you aware that said drawings, Exhibit C, are the drawings, or copies of the drawings, annexed to the original specification of the English patent, Exhibit C, in the printed record, and are a part of Exhibit C in the printed record?

Ans. I am not aware of that fact, having never, so far as I now recollect, seen the original drawings.

Cross-int. 227. Are you not aware of the fact that the drawings marked "Sheet 1, Defendant's Exhibit C, C. W. T., examiner," of which you have been testifying, are a part of defendant's exhibit C, C. W. Tuttle, examiner, found on pages 78 to 85 inclusive, in the printed record?

Ans. I believe them to be such.

Cross-int. 228. Do you not understand and believe said Exhibit C to have been the original English patent, subsequently patented in this country, and reissued as complainant's exhibit No. 1 on which this suit is brought?

Ans. I believe it to be a copy of said English patent, and that it is the one upon which this suit is brought.

Cross-int. 229. Assuming that to be the case, and finding no such sectional drawings in Exhibit 1, as exhibit the radial bars, partitions or feathers, and finding them in the drawings in Exhibit C, would you not seek in said drawings in Exhibit C for information regarding them?

Ans. I would not; but would seek for such information, or for the requisite information to enable me to construct a valve in accordance with the views of the inventor, in the description which he has given of the invention.

212 Cross-int. 230. Would you pay no attention to the drawings of the original English patent, Exhibit C, on points wherein the drawings of the reissued patent are silent?

Ans. I should pay some attention to the drawings if they were so made as to correctly illustrate the clearly-expressed intentions of the inventor; but if a conflict were found to exist between the drawings and the description, I should disregard the drawings and follow the instructions given in said description; especially when, as in this case, there is no model by which to verify the correctness of the drawings.

Cross-int. 231. You mean, then, that you would examine the original English drawings in Exhibit C, but if you found them in conflict with the expressed intentions of the inventor, you would disregard them and follow the instructions given in the description?

Ans. That is what I have said.

Cross-int. 232. What, studying the drawings alone, would you conclude the dotted lines in figure 1, Exhibit 1, to indicate?

Ans. I should conclude them to indicate openings or passages through a diaphragm in the space between the outer casing of the valve and the steam-conduit.

Cross-int. 233. What, reading said drawings alone, indicate the size of said openings?

Ans. There is nothing to indicate their size, because there is no pretence that the drawing is made to any scale; but the proper size would

have to be determined by the judgment of the constructor and by experiments made with a valve after it had been constructed.

Cross-int. 234. Many of the drawings, figure 1, of the reissued specification represent a valve of full size?

Ans. It is difficult to answer this question, because a valve like figure 1 might be said to be a full-sized valve for a certain purpose, while a valve five or more inches in diameter would only be a full-sized valve for another purpose; and if the dimensions of the drawing are to be taken as a guide, it could not be said to represent a valve of the last-named dimension.

Cross-int. 235. If drawings of a valve of full-sized dimensions
213 for one purpose are given, is there any difficulty in making, with that as a guide, valves of any size?

Ans. There is.

Cross-int. 236. Explain the difficulty.

Ans. The difficulty arises from various causes; in the first place, if a valve one inch in diameter is made to operate to the best advantage, and another, of say four or six inches, is made with all the diameters made large in proportion to the increase in the size of the valve, it would operate very differently from the one that was one inch in diameter, if it would operate at all. There are other elements to be taken into the account, such as the friction of the steam in the passages leading to the valve and from it, the removal of a portion of the atmospheric pressure from the upper surface of the valve, the friction of the steam in the conduit being greater in proportion to the volume passed out in a small valve than it is in a larger one. There is another difficulty which would be experienced, which is, that in taking measurements from a drawing it is difficult to get the exact dimensions of the parts measured, and especially when it relates to small passages between two solid bodies. Any difference made in the measurement of the smaller valve would not, of course, effect the operation thereof, to the same extent that it would in the larger one; as for instance, suppose an error of one-hundredth of an inch in the diameter of the overhanging lip of the valve to be made in the case of the smaller one, its effect would be very different if a like error was made in the larger one; and the same would be true in reference to the space between the lip of the valve and the casing thereof.

Cross-int. 237. Do you not understand in Exhibit 1 that figure 1 represents a one-inch valve, that figure 4 represents one-half the size of a two-inch valve, and figure 5 one-fifth of the size of a five-inch valve?

Ans. There is nothing in said drawings to lead me to understand that they do represent the sized valves referred to in the question; but in looking at the specification I find it stated that "figures 1 and 2 of the annexed sheet of drawings represent respectively a vertical sec-
214 tion and a front elevation of a safety-valve constructed according to my invention;" and I further find it stated that figure 4 represents a vertical section of a two-inch locomotive-boiler safety-valve; figure 5 represents a vertical section of a portion of a five-inch safety-valve adapted for large marine or land boilers, constructed according to this invention; without the information derived from the specification it would never have occurred to my mind that the drawings were intended to show such a variety of valves.

Cross-int. 238. What do the words "half size," in said drawings opposite figure 4, mean, and what do the words and figures "one-fifth full size," opposite figure 5, mean?

Ans. I have no doubt that they mean what they say, and that I was

in error in my last answer in saying that there was nothing in said drawings that would indicate the size of the valves there shown.

Cross-int. 239. Do not the words first quoted in your last answer but one, namely, "figures 1 and 2 of the annexed sheet of drawings, represent respectively a vertical section and front elevation of a safety-valve constructed according to my invention," indicate that said figures represent a full-sized valve?

Ans. They do not, in my judgment, except as before described, that it might be a full-sized valve for certain purposes. I desire to add here, that when I answered cross-interrogatory 237 I understood the question to be, "Do you not understand in Exhibit 1 that figure 1 represents a one-inch valve, that figure 4 represents one-half the size of a two-inch valve, and figure 5 one-fifth of the size of a five-inch valve?" To this I answered, "There is nothing in said drawings," by which I meant the figures referred to, "to lead me to understand that they do represent the sized valves referred to in the question." If the explanation of said figures is not to be regarded as a part of the figures, then I adhere to the answer there given, and my answer to the following question is not correct, but if the interpretation given to these explanatory notes is such as to include said notes as part of the figures referred to, then my answer to cross-interrogatory 238 will convey my meaning.

(Adjourned to Wednesday, March 5, at 10 a. m.)

215 WEDNESDAY, *March* 5—10 a. m.

Cross-int. 240. Is there anything else in the drawings alone of Exhibit 1, except the fact that the walls of the valve-casing and the steam-conduit appear to be a little thicker where the dotted lines are than elsewhere, to indicate that the space between said dotted lines represented a diaphragm rather than radial bars?

Ans. I do not see that there is, except the dotted lines themselves.

Cross-int. 241. Do you not observe that on the left-hand of figure 1 in said drawing, and immediately above exit-pipe B, the dotted lines are in an exact line with the rest of the wall of the valve-casing?

Ans. I observe that they are not on an exact line, but that the outer dotted line, at the part referred to, is nearer on a line with the outer wall of the casing than are some of the others; but this undoubtedly arises from the fact that the draughtsman was a little careless in drawing that dotted line.

Cross-int. 242. Does not the fact that said dotted line is so nearly in a line with the wall of the valve-casing tend to show that the draughtsman may have been careless or hasty in drawing the other dotted lines, and cause you to attach less importance to the fact that said dotted lines are not generally in a line with the valve-casing?

Ans. It does not.

Cross-int. 243. Would you, from said drawings, conclude that the diaphragm was as thick as the space covered by black lines between said dotted lines?

Ans. I should conclude that it was so shown in the drawing, but I should not conclude that the constructor was limited to the thickness there shown, or to any other thickness.

Cross-int. 244. Does the word diaphragm appear in the specifications of Exhibit 1, anywhere else than at the close of the bottom of page fifteen and the top of page sixteen of the printed record, where a rubber diaphragm to prevent injury to the spring from salt water is mentioned?

Ans. It does not.

216 Cross-int. 245. Is there anything in the specification Exhibit 1 which directs chamber D to be separated into two parts?

Ans. I think there is. I find the following language in the specification which I understand to be intended to give such directions: "My invention also consists in the valve C, constructed with projecting downward curved lip or periphery, and in the chamber D, surrounding the valve-seat," and I further find that the third clause of the claim reads as follows: "The annular recess D, surrounding the valve-seat, substantially as herein set forth." Such instruction being given, I am brought to the conclusion that there must be something which can properly be called a recess, and that such recess must be in immediate proximity to the valve seat and surrounding the same; and that it does not refer to the chamber which is below the diaphragm, as such chamber cannot be said to surround the valve-seat.

Cross-int. 246. Is it your opinion that, in a valve constructed according to Exhibit 1, figure 1, all the steam is directed downward?

Ans. It is not; I suppose that the tendency of steam to expand so soon as it is relieved from pressure would cause a portion of it to pass up around the lip of the valve.

Cross-int. 247. Would not that be the case if all in the first instance were directed downward?

Ans. In a case like the one supposed in question, after a sufficient amount of steam had been discharged into the chamber to fill the same it would react against the bottom of said chamber, after which a portion of it would pass up around the lip of the valve.

Cross-int. 248. Does not that suppose all the steam to be in the first instance deflected downward?

Ans. I do not think it possible in a valve constructed as shown in figure 1, Exhibit 1, to reflect all the steam downward for any considerable distance below the lower edge of the lip of the valve; for, as I have before stated, its tendency to expand would be likely to cause a portion of it to pass up around the lip.

Cross-int. 249. Would not that be due in a valve so constructed to the expansive force of the steam overcoming the direction given it by the curved lip of the valve?

217 Ans. I cannot understand how the expansive force of steam can have anything to do with overcoming the direction in which it may be traveling.

Cross-int. 250. Suppose the chamber D to be sufficiently open to exit-passage B, and exit-passage B also sufficiently open easily to discharge all the steam from the valve, would not the deflection given the steam by the lip around the valve, as constructed with the lip of the valve curved, as represented in said figure 1, be sufficient to deflect all of the steam from the valve downward into chamber D?

Ans. I do not understand what is signified in the question by the word "easily"; but if it means that the exit passage B is to be so large as not to form any obstruction to the passage of the steam through it, after it has expanded as much as it can in the chamber with which the nozzle B communicates, and there is no obstruction in any other part of the path in which the steam travels, it is probable that when a sufficient amount of steam was passing the curved lip of the valve, that much the largest proportion of it would be directed downwards.

Cross-int. 251. Is not your opinion that with the exit-passage constructed as supposed in your last answer, all the steam would be deflected downwards?

Ans. I suppose that with a very small quantity of steam admitted

into the chamber, it would not all be deflected downwards for any considerable distance below the lip of the valve; but that, when a sufficient amount of steam was admitted to make its momentum sufficient to cause it all to pass out at the nozzle B, without obstruction, it would all be directed downwards, and would also induce a current of air to pass in around the lip of the valve, and be discharged with the steam, the result of which would be an extra load upon the valve.

Cross-int. 252. Suppose a valve constructed after the design of figure 1 of Exhibit 1, and chamber D entirely open between the walls of the steam-pipe and the valve-casing, excepting only four radial bars one-eighth of an inch in thickness, and nozzle B and other parts of
218 the valve of the dimensions represented in said drawing, would not, in your opinion, all of the steam pass out of nozzle B?

Ans. I do not think it would.

Cross-int. 253. Would the larger part pass through the nozzle B?

Ans. I should say that it would.

Cross-int. 254. How much the larger part?

Ans. I suppose the proportions passing in the different directions would be about equal to the proportionate areas of openings; I mean now, when a sufficient amount of steam was passing to create a pressure in the chamber with which the nozzle communicates.

Cross-int. 255. What lift of the valve would be required to produce that effect in the case supposed?

Ans. I should presume that one-sixteenth of an inch or more of lift would produce such an effect.

Cross-int. 256. Would there in your judgment be any period of lift in the case supposed when all the steam would pass out through nozzle B?

Ans. I do not think there would.

Cross int. 257. You refer in your answer to cross-interrogatory 245 to the words "annular recess D surrounding the valve-seat," as a reason for believing that a diaphragm was intended in immediate proximity to the valve-seat and surrounding the same, because the chamber below could not be said to surround the valve-seat; is not the annular chamber D described as surrounding the central passage A, as well as the surrounding valve-seat?

Ans. It is; and it is this fact that confirms me in my opinion that the chamber D is to be divided by some suitable means, one part of which is called the recess D and surrounds the valve-seat, while the other portion is called chamber D surrounding the central passage A.

Cross-int. 258. Do you really attach much importance to such use of the words "recess" and "chamber," the same letter being used?

Ans. I do; because I believe that in the specification they are intended to be described as two spaces, and not as a single one.

Cross-int. 259. Is not chamber D described in the specification as communicating with the exit-pipe B?

Ans. It is; but in this case reference is had to the chamber below the diaphragm, and not to the recess above it.

219 Cross-int. 260. Do you not find in the drawing of Figure 1, in Exhibit 1, that the letter D is there found only in those parts of the chamber above the dotted lines; and when the specifications say that said chamber communicates with exit-pipe B, does not that indicate that the chamber D referred to, is intended to be, and is, spoken of as a unit?

Ans. I do find in the figure alluded to, that the letter D appears only in that portion of the chamber or recess which is above the dotted lines.

I do not, however, conclude that the two are a unit in so far as their effects are concerned, because of this fact; the upper portion, whatever it may be termed, does communicate with the passage B through the aperture formed in the parts which separate the two portions.

Cross-int. 261. Do you not find in Exhibit 1, on page 13 of the printed record, from the 12th to the 19th lines from the top, inclusive, the only direct language in the specifications which tells by what means a portion of the steam will be directed downwards, and leaving out some of the language may it not be read thus: "I make this valve to curve its projecting edges slightly downward, so that the steam will impinge against the curved projecting portion of the valve, and a portion of it will be directed downward into the annular chamber D"?

Ans. I do find that the portion of the specification referred to in the question is the only portion in which instructions are given for turning a portion of the steam downward; the language could be changed as suggested, and read as changed, but it would not convey to the mind of a person skilled in the art the same meaning that it does as it now stands.

Cross-int. 262. Why not?

Ans. Because it would then give the impression that the steam was directed downwards into a chamber consisting of one part only, and that that portion was the one surrounding the valve-seat; whereas the words which immediately follow the quotation which ends cross-interrogatory 261 are, "surrounding the central passage A," thus making it clear to my mind that that portion of the chamber which is below the diaphragm, is distinguished from that portion which is above, and is said to surround the valve-seat.

Cross-int. 263. Please read said question 261 as if the words quoted in your last answer were added to it, to wit, the words, "surrounding the central passage A," and then state by what means said language says a portion of the steam will be directed downward.

Ans. By the curved lip of the valve.

Cross-int. 264. Does not said language then say, substantially, that the lip of the valve is curved so slightly downward that a portion of the steam will be thereby directed downward?

Ans. The language referred to is as follows: "I make this valve to project over the edges of the exit-passage A, and to curve its projecting edges slightly downward, as shown in Figure 1, so that the steam on issuing between the valve and its seat will impinge against the curved projecting portion of the valve, and a portion of it will be directed downward into the annular chamber D, surrounding the central passage A, and communicating with exit-pipe B, while the other portion of the steam ascends past the edge of the valve." From this description it will be seen that no attempt is made to give directions for determining the quantity or proportion of the steam directed downwards, or of the proportion to be directed upwards; neither is any direction given as to the degree of curvature to be given to the under side of the lip, the only requirement being that it shall be such as to direct a portion downward, while the other portion is to pass up around the lip.

Cross-int. 265. In your answer to the 9th direct interrogatory, in quoting from Exhibit C, on pages 81 and 82 of the printed record, you stopped at the word "opened," in the fifth line of the 82d page, in nearly the middle of a sentence; what is the rest of said sentence, and why did you omit said portion of said sentence?

Ans. The rest of the sentence reads as follows: "But I wish it to be understood that I lay no claim to such recoil action, nor to the exten-

sion of the valve laterally beyond its seat." In quoting that portion of this sentence which is given in the answer to the question referred
221 to, I stopped at that point because I believed that I had quoted enough to illustrate my meaning, and not because I had any desire to suppress the balance of the sentence.

(Adjourned to Thursday, March 6, at 10 a. m.)

THURSDAY, *March* 6—10 a. m.

Cross-int. 266. You have spoken of an experiment made with what purported to be a Beyer valve; at what pressure did said valve close?

Ans. My minutes with reference to said experiment, which were taken at the time of trying it, are as follows: "The valve set to commence blowing slightly at seventy-seven pounds; the pressure went up to eighty-five pounds; no sudden rise; no sudden relief of pressure; lift of valve one thirty-second of an inch; did not fall at all."

Cross-int. 267. Didn't the valve close?

Ans. Not until after the stop-valve had been closed in the pipe which conducted the steam to the safety-valve.

Cross-int. 268. Did you make no other experiment with said valve?

Ans. I did; one other.

Cross-int. 269. What was that, and when?

Ans. It was on the same day or the day following, the one previously described having been on the 6th of January. It was similar in all respects to the first experiment, tried in the same place, upon the same pipe, and with the same gauge upon the boiler. In the last-named experiment the valve was set to blow slightly at seventy pounds pressure, and rose to seventy-nine pounds; the lift of the valve was the same as in the previous experiment, as nearly as I could determine, and the stop-valve was closed before the closing of the safety-valves, as in the previously described experiment.

Cross-int. 270. Did you try no experiment with said valve wherein the pressure in the generator was reduced so as to permit the valve to close automatically?

Ans. I did not.

Cross-int. 271. Was the stop-valve closed slowly so as to enable you to tell at what point of pressure said valve would close automatically?

222 Ans. It was not.

Cross-int. 272. Did said valve operate in any way different from the operation of the common safety-value with the beveled edge or ground joint?

Ans. I did not observe that it did, although I had no such comparison in my mind at the time.

Cross-int. 273. Did it not open to a greater extent than the common safety-valve would under like circumstances?

Ans. I think it did.

Cross-int. 274. Did it not open more promptly after the steam began to escape from the ground-joint?

Ans. I cannot answer this question intelligently, for the reason that there is great difference in the action of what is here termed the common safety-valves, some of which rise more promptly than others.

Cross-int. 275. Did not the Beyer valve have a second upward lift after the steam had begun to escape from the ground joint?

Ans. It had a regular lift from that time to the time that it reached its highest point, as nearly as I remember.

Cross-int. 276. If said valve were made with the outer edges of the

two flanges *a*, *b*, made so as to approximate nearer to each other, would it not have a second distinct lift upward?

Ans. I do not think it would.

Cross-int. 277. If the distance between the two flanges *a*, *b*, was greater near the ground-joint, and between the outer edges of said flanges smaller, would it not have a second distinct lift upwards?

Ans. In this question I am required to give an opinion in the case of a supposed change, without any degree of such change being given, which makes it a very difficult question to answer, and I can only say that any alteration in that direction which could be made in a valve of the size of that shown in drawings of Exhibit A, would not, in my judgment, produce the effect spoken of in the question.

Cross-int. 278. What alteration in the size of the valve would be necessary in order to enable you to obtain such result by the means supposed?

Ans. I doubt if any alteration in the size of the valve would enable it to produce the result supposed.

223 Cross-int. 279. Do you think that no change in the space between the flanges *a*, *b*, by enlarging the distance between said flanges near the ground joint and diminishing the distance between them at the outer edges of said flanges, would produce the result supposed?

Ans. I do.

Cross-int. 280. What forces in the case supposed in the last interrogatory, if any, would act upon the concave flange *b*?

Ans. The impinging force of the steam would be the principal one; there would, however, I think, be a very limited force derived from the expansion of the steam between the lips *a*, *b*, but this would be so slight as hardly to be perceptible, if it were at all perceptible, and would be a constantly diminishing force from the time the valve left its seat until it had reached its highest point, and, consequently, there would be nothing to give the extra amount of force required to cause the sudden rising of the valve.

Cross-int. 281. In the specification of Beyer, Exhibit A, on page 71 of the printed record, he says: "It is well known that the common or-ordinary safety-valve, when loaded to counterbalance a given pressure of steam, does not lift or blow off freely until the pressure has increased to a considerable extent above the pressure fixed upon; consequently, the boiler is but slowly relieved of the excess of pressure, owing to the small area of the opening of the valve. The object of this invention is, wholly or partially, to remove this defect, by causing the safety-valve, when the pressure has become sufficient to overcome the weight upon it, to lift much higher than the ordinary safety-valve, and thus give a larger opening for the escape of the steam or other fluid." Is it your opinion that said invention failed in its object?

Ans. It is my opinion that, to a great extent, it did fail in its object; and I think that the experiments above alluded to are good evidence of the correctness of my opinion.

Cross-int. 282. In said Exhibit A, on page 72 of the printed record, the inventor says: "When the steam begins to escape from between the surfaces of the valve, it gets between the concave and convex surfaces of the two flanges, and its force thus acts upon a larger area and

224 reacts upon the concave surface of the valve, and causes it to open to a greater extent than the ordinary safety-valve." Is it your opinion that the inventor has not correctly stated the operation of his valve?

Ans. It is; in so far as the statement relates to the additional lift to the valve, it does, I think, as I have before stated, rise a little higher than the common safety-valve; but this additional rise is due, as I believe, much more to the impinging force of the steam acting on the under side of the lip than to any reacting force within the space formed by the flanges *a*, *b*.

Cross-int. 283. On said page 72 of the printed record the inventor, Beyer, further says: "This improved valve will, as before stated, lift promptly when the required pressure is attained, and will open to a much greater extent than the common safety-valve." If you are of opinion that said Beyer's valve, constructed according to the drawing of said Exhibit A, will not thus act, what alteration, if any, of the space between said flanges *a*, *b*, and of the outer edges of the flanges, or of either, would cause said valve to operate according to the description in said last quoted sentence?

Ans. I cannot tell what the inventor means by the words "lift promptly," or what he means by the words "to a much greater extent;" if his meaning is that the valve will rise suddenly to a height sufficient to relieve the excess of pressure in the boiler, then, as I have before stated, I do not think that any change of the space between the lips of the valve could be made to produce such an effect.

Cross-int. 284. Couldn't you, by varying the space between the flanges, increase the elastic or expansive force upon the valve of the steam therein?

Ans. If that space were supposed to be of any given area, and that area was enlarged, there would be a greater amount of steam in such area when the valve was blowing; and, consequently, theoretically speaking, there would be a very slight increase of force acting upon the valve; but this would clearly be so trifling a difference as not to be observable in practice.

Cross-int. 285. Please simply point out the language in the specification of Exhibit 1 which directs the contracting of the exit-passages below the valve.

225 Ans. I do not find any language which expressly directs such contraction to be made; I do find the following: "I make the valve project over the edges of the exit-passage A and to curve its projecting edges slightly downward, as shown in Figure 1, so that the steam, on issuing between the valve and its seat, will impinge against the curved projecting portion of the valve, and a portion of it will be directed downward into the annular chamber D surrounding the central passage A, and communicating with exit-pipe B; while the other portion of the steam ascends past the edge of the valve."

Cross-int. 286. Were Exhibits 3 and 4 made because of, and to correspond with, said language?

Ans. They were made to correspond with said language, I believe; but I do not know whether they were made because of it or not.

(Adjourned to Friday, March 7, at 10 a. m.)

FRIDAY, *March* 7—10 a. m.

Direct examination resumed.

Int. 287. Please examine the diagram marked "Complainant's Exhibit 6," and state whether it correctly represents the arrangement of the steam-pipes connected with the boiler upon which the experiments which you have testified about with the several exhibits in this case were made?

Ans. I have examined the exhibit, and find that it does correctly represent the pipe upon which the valves were placed while being tested.

Int. 288. State whether it also indicates the position of the valve during the experiments?

Ans. It does.

Int. 289. Please state whether you made any, and what, experiments to determine the relative pressure of the steam in the pipe upon which the valve was placed and the pressure of the steam in the boiler?

Ans. I did make such experiments, and in the following-described manner: A steam-gauge was placed upon the pipe at the point indicated on the diagram, and another of like construction was placed
226 upon the boiler, both gauges being in plain view from the point where I stood during the time the experiments were being tried, and both gauges indicated the same pressure. In order to make this experiment as satisfactory as possible, the two gauges spoken of were tested side by side with a column of mercury previous to being put in position as above described, and no difference was found to exist in the indicated pressure upon them. These gauges were observed before the valve suddenly rose, and while it was at its highest point; and at no time was there any observable difference in the pressure indicated by them.

Int. 290. What is the theoretical velocity with which air will flow into a vacuum if unobstructed and what is the actual velocity in practical operation?

Ans. The theoretical velocity is 1,347.4 feet per second; the actual velocity 952.61 feet. My authority for this statement is found in the "Engineers and Mechanics' Pocket-Book, by Charles H. Haswell, civil and marine engineer," and upon page 391.

Int. 291. Do you find it stated in that book, and if so, on what page, the observed pressure per square foot of air in motion at any and what velocity?

Ans. Upon page 423 of the same book I find it stated that "the force of wind upon a surface perpendicular to its direction has been observed as high as fifty-seven and three-fourths pounds per square foot; velocity 159 feet per second."

Int. 292. State whether or not the book from which you have quoted above is regarded among mechanical engineers and others as authority upon the subjects therein treated.

Ans. It is very generally accepted as authority upon such subjects, and it is within my knowledge that it is constantly consulted by engineers and constructors; and that it is the text-book in use in at least one of the largest navy-yards in the country, namely, the Washington yard.

Int. 293. Can you state the relative increase of pressure to the increase of velocity of wind from any, and what authority? If yea, please do so.

Ans. In Chambers' Encyclopædia, volume 10, page 213, I find
227 the following: "The force of the wind is measured by anemometers (*q. v.*), of which some measure the velocity and others the pressure. The following are a few of the velocities of wind, translated into popular language: seven miles an hour is a gentle air; fourteen miles, a light breeze; twenty-one miles, a good, steady breeze; forty miles, a gale; sixty miles, a heavy storm; and eighty to one hundred miles, a hurricane, sweeping everything before it. We also add a few comparisons of velocity and pressure: five miles an hour is a pressure of two ounces upon the square foot; ten miles, one-half pound; twenty miles, two pounds; thirty miles, four and a half pounds; forty miles, eight pounds; fifty-one miles, thirteen pounds; sixty miles, eighteen

pounds; seventy miles, twenty-four pounds; eighty miles, thirty-two pounds; and one hundred miles, fifty pounds."

Int. 294. Please examine Complainant's Exhibit No. 7, and state whether it conforms to the valve shown in Defendant's Exhibit M.

Ans. It does, in all its essential features.

Int. 295. Is there any variation in the opening for the escape of the steam into the air from a valve constructed like that, when the valve is raised from its seat one-sixteenth of an inch, or during the time it is rising?

Ans. There is not any difference that is susceptible of being measured, or that, in practice, would make any difference in the operation of the valve.

Int. 296. Is there any appreciable difference in the size of that opening when the valve is raised one-twelfth of an inch from its seat?

Ans. I do not think that there is.

Int. 297. What would be the relative capacity of an annulus five-sixteenths of an inch in width around a cylinder two inches in diameter, and an annulus of the same width around a cylinder one inch in diameter?

Ans. The one around the two-inch cylinder would be twice the capacity of that around the one-inch.

Int. 298. What would be the relative capacity for the discharge of steam from the ground joint of a valve one inch in diameter and a valve two inches in diameter at equal lifts of the valve?

228 Ans. The valve having the diameter of two inches would have a capacity twice as great as that of the valve one inch in diameter.

Int. 299. What is the lift, ordinarily, of the common safety-valve?

Ans. I think the average of common safety-valves is not more than the one-hundredth part of an inch.

(Adjourned until Saturday, March 8, 1873, at 11 a. m.)

SATURDAY, *March* 8, 1873—11 a. m.

(Adjourned until Monday, March 10, 1873, at 10 a. m.)

MONDAY, *March* 10, 1873—10 a. m.

(Adjourned to Tuesday, March 11, 1873, at 12 m.)

TUESDAY, *March* 11, 1873—12 m.

Int. 300. Would a valve constructed like that shown in figures 1 and 2 of the drawing of the complainant's reissued patent, Exhibit 1, supposing that part of the drawing over which vertical dotted lines are shown, to represent radial bars, or feathers (as they have been termed in your cross-examination), operate substantially like Exhibit 3, which has a perforated diaphragm in place of such radial bars?

Ans. I have no doubt that it would.

Int. 301. Please examine Complainant's Exhibit No. 8, and state whether or not that is constructed like figures 1 and 2 of said reissued patent, but having radial bars in that part of the valve represented in the drawing in the section by oblique parallel black lines and vertical dotted lines.

Ans. I have examined the exhibit referred to in the question, and found it to be substantially like the valve represented by figures 1 and 2 of the drawings of Exhibit 1; the only difference which I have been able to discover is that the valve is larger in diameter in the Exhibit No. 8 than that shown in the drawings, and the arrangement of

229 the spring which holds the valve to its seat is also different, it being the same in this case as in the exhibits heretofore referred to.

Int. 302. Have you made any, and what, experiments with Exhibit No. 8, and with what results?

Ans. I have made an experiment with the exhibit referred to in the question; the valve being set to blow slightly at sixty-one pounds pressure per square inch, it rose suddenly, or "popped," as it has been termed, at sixty-one and three-fourths pounds, relieved the pressure in the boiler and closed at fifty-nine and a half pounds, the lift of the valve being one-twelfth of an inch. I also tried another experiment with a pressure in the boiler of seventy-five pounds, at which point the valve commenced to blow slightly, and "popped" at seventy-five and a half pounds, relieved the pressure in the boiler and closed at sixty-nine and a half pounds; the lift of the valve in this experiment was three-thirty-seconds of an inch. In both of these experiments steam passed up around the lip of the valve with considerable force.

Int. 303. Please examine Complainant's Exhibit No. 9, and state how it differs from Exhibit No. 8, and state whether you made any and what experiments with said Exhibit No. 9, and with what result, and when the experiments were made.

Ans. I have examined the exhibit, and find it to differ from Exhibit No. 8, in that it has no radial bars across the space between the casing and the central passage, but is entirely open and free from any obstruction down to the bottom of the chamber which surrounds said central passage. I have made an experiment with this valve with the following result: the valve was set to blow slightly at a pressure of sixty-one pounds; the pressure increased to sixty-two and one-fourth pounds, when the valve "popped"; it immediately commenced relieving the pressure in the boiler, and closed at fifty-eight pounds, the lift of the valve being as nearly as possible one-twelfth of an inch; a second experiment was tried in all respects like the one just referred to, so far as the pressure to which the valve rose, the "popping," and relieving of the pressure in the boiler were concerned; but, in this case, the valve closed at fifty-seven and a half pounds. In these experiments a portion
230 of the steam escaped up past the lip of the valve to as great an extent apparently as it did in the experiments tried with Exhibit No. 8; these experiments were made on Thursday, March 6, 1873.

Int. 304. Please examine Complainant's Exhibit No. 10, and state whether the valve is constructed substantially in accordance with the complainant's said reissued patent, and whether the substitution of the recess in said exhibit for the annular chamber shown in figures 1 and 2 of the drawings of said reissued patent makes any substantial difference in the mode of operation of the valve?

Ans. I have examined the exhibit, and believe that it is constructed substantially in accordance with the reissued patent of the complainant; because I find that "the projecting lip of the valve and the annular recess are available in causing an increased pressure on the valve"; and because the valve is made "to curve its projecting edges slightly downward, as shown in figure 1, so that the steam on issuing between the valve and its seat will impinge against the curved projecting portion of the valve."

I do not think that the substitution of the recess spoken of for the annular chamber does make any substantial difference in the mode of operation.

Int. 305. Did you make any, and what, experiments with Exhibit No. 10, and with what results?

Ans. I did make an experiment with the following-named results: the valve was set to blow slightly at eighty pounds per square inch on the boiler, rose suddenly or "popped", as it is termed, at eighty and one-half pounds, relieved the pressure in the boiler and closed at seventy-six and one-half pounds; lift of valve one-twelfth of an inch.

Int. 306. Where were these experiments made about which you have testified to-day?

Ans. On the premises of M'r E. H. Ashcroft, at the same place and with the same apparatus that those about which I have previously testified were made.

Int. 307. State whether in the several experiments made by you with the Naylor valve, about which you have testified, the pressure
231 in the boiler increased or not after the several valves opened suddenly, or "popped"?

Ans. It did not.

Cross-examination resumed:

Cross-int. 308. Was there not an implement for closing and opening the globe stop-valve not represented on complainant's exhibit 6; and, if yes, what was it?

Ans. There was a rod of iron attached to the hand-wheel represented in the exhibit, by which the valve could be opened and closed; this rod extended from the top valve to the side of the arch, and had a cross-arm upon its end; such a rod or some equivalent means being necessary to enable the operator to open the valve without getting upon the heated brick-work surrounding the boiler.

Cross-int. 309. What is the distance between the gauge on the pipe in which the experiments were made to the front end of the brick-work encasing the boiler?

Ans. I did not measure it myself; but I notice that in the diagram it is marked two feet four inches.

Cross-int. 310. With what valve on the pipe did you make the experiments detailed in your answer to interrogatory 289?

Ans. I think it was a valve with a casing like Exhibit No. 10; what the construction of the valve itself was I do not know, and I do not think I examined it.

Cross-int. 311. How long did the valve remain open after it suddenly rose?

Ans. Perhaps one minute; I cannot state the exact period of time, as I did not pay any particular attention to it.

Cross-int. 312. At what pressure did it suddenly rise?

Ans. At about sixty pounds.

Cross-int. 313. At what pressure did it close?

Ans. I do not know.

Cross-int. 314. Did the pressure increase after it had suddenly risen?

Ans. I think it did not.

232 Cross-int. 315. Did you take any minutes of those experiments?

Ans. I did not.

Cross-int. 316. Did you try more than one experiment of that kind?

Ans. I did; two, and I think three.

Cross-int. 317. When were those experiments made?

Ans. One week ago last Wednesday.

Cross-int. 318. Were they all with the same valve on the pipe?

Ans. I think they were.

Cross-int. 319. Do not the published works upon steam and steam

engines give any information as to the effect upon the pressure of steam conducted through pipes?

Ans. Under certain circumstances they do.

Cross-int. 320. What information and under what circumstances?

Ans. I have seen it stated by some author, whose name I cannot give at present, that in a pipe having twenty square or right-angled turns formed in it, attached to a generator having twenty pounds of steam, its pressure would be so diminished as that it would only pass freely into the atmosphere at the end of such pipe, the outer end of said pipe in such case being entirely open; but this statement can have no reference to the action of steam in a pipe the outer end of which should be closed, as in such a case the pressure would be the same at the outer end that it was at any other part of the pipe.

Cross-int. 321. How much did said author state the pressure would be diminished?

Ans. I have given the language of the author as nearly as I recollect it.

Cross-int. 322. Is that the only publication you remember upon that subject?

Ans. Upon that particular subject, it is.

(Adjourned until Wednesday, March 12, A. D. 1873, at 11 a. m.)

233 WEDNESDAY, *March* 12, 1873—11 a. m.

(Adjourned until Thursday, March 13, 1873, at 10 a. m.)

THURSDAY, *March* 13, 1873—10 a. m.

Cross-int. 323. Please look in the book of Charles H. Haswell, to which you have already referred, and state what he says on the velocity of flow of steam into the atmosphere per second.

Ans. He gives a table headed as follows: "Velocity of flow of steam into the atmosphere, per second," of which the following is a copy:

Pressure above atmosphere.	Velocity.	Pressure above atmosphere.	Velocity.	Pressure above atmosphere.	Velocity.
Lbs.	Feet.	Lbs.	Feet.	Lbs.	Feet.
1	482	10	1,241	50	1,791
3	791	20	1,504	70	1,877
5	973	30	1,643	100	1,957

Cross-int. 324. Please look on page 118 of a work entitled "A Treatise on the Steam-engine, in its Various Applications to Mines, Mills, Steam Navigation, Railways," &c., by John Bourne, imprinted in London, in 1861, and state what you there find on the velocity of efflux of high-pressure steam into the atmosphere.

Ans. I find a table headed "Velocity of efflux of high-pressure steam into the atmosphere," of which the following is a copy:

Pressure of steam above the atmosphere.	Velocity of free efflux in feet per second.	Pressure of steam above the atmosphere.	Velocity of free efflux in feet per second.
Lbs.	Feet.	Lbs.	Feet.
1	482	50	1,791
2	663	60	1,838
3	791	70	1,877
4	890	80	1,919
5	973	90	1,936
10	1,241	100	1,957
20	1,504	110	1,972
30	1,643	120	1,990
40	1,729	130	2,004

234 Cross-int. 325. Look at page 159 of said record, and state what you find there on the flow of air through tubes.

Ans. I find a paragraph headed "Flow of air through tubes," of which the following is a copy: "The efflux of air from vessels, and its flow through tubes, are governed by the same laws which apply in the case of water; when air escapes through an orifice in a thin plate, the effective diameter of the orifice is reduced, as in the case of water, by the action of the contracted vein; and when air passes through pipes its velocity its diminished as in the case of water, by the friction it suffers against the sides of the pipes. It appears from Koch's experiments, that with pressure of one-two-hundredths to one-fifth of an atmosphere, the actual discharge of air through an orifice in a thin plate is 0.58 of the theoretical discharge; but if a nozzle like that of a bellows is added the actual discharge rises to 0.85 of the theoretical discharge. The theoretical velocity of air may easily be determined by finding the height of a column of air which would produce the pressure, and the velocity which a heavy body would acquire by falling from that height."

Cross-int. 326. Please look on page 598, volume 20, Encyclopædia Brittan'ica, chapter 4, 8th edition, entitled "The behavior of steam in the cylinder during admission," and state what you there find in relation to the passage of steam through pipes.

Ans. I there find the following: "In the flow of steam from the boiler to the cylinder it meets with hindrances to its passage, which usually operate to cause a considerable reduction of pressure when it reaches the cylinder, even if all the passages be thrown wide open. The actual charge of steam transmitted through an irregular passage of considerable length, and of a given sectional area, is, in all cases, less than what can be passed through an aperture of a very short length, as in a thin plate of the same sectional area, owing to the bends and lateral friction of the long passage. It therefore frequently happens that the opening of the part allowed by the valve, though it may be much less than the total area of the part, is sufficiently large to pass all the steam that can force its way along the passage. This fact is constantly exemplified in practice; it is known that opening the part beyond a certain
235 amount, in all cases less than the area of the part itself, ceases to be advantageous in facilitating the passage of the steam into the cylinder. Similarly, the opening of the regulator or "throttle-valve," beyond a small fraction of the sectional area of the steam-pipe, does not add to the available pressure of the valve-chest. When the steam is not dry, or contains water in suspension, the labor of moving in passages is greatly increased, owing to the quantity of dead inelastic weight to be dragged along, and the reduction of pressure is consequently much more than with dry steam."

I cannot understand what bearing the above-quoted matter, in answer to cross-interrogatories 323, 324, 325, and the one just answered, has upon the experiments about which I have testified, as the circumstances vary so widely as in my judgment to preclude the possibility of their being at all parallel cases.

Cross-int. 327. When were the Exhibits 8, 9, and 10 made?

Ans. I do not know.

Cross-int. 328. When did you first see them?

Ans. I saw, I think, Exhibits 8 and 9 on Thursday or Friday of last week, and Exhibit 10 for the first time on Monday or Tuesday of the present week.

Cross-int. 329. When the experiments of Exhibits 8, 9, and 10, about which you have testified, were being made, was the engine running?

Ans. It was.

Cross-int. 330. Was the pipe for heating the building open or closed?

Ans. It was closed.

Cross-int. 331. Who closed it?

Ans. I cannot tell who closed it, as it was closed when I commenced the experiments.

Cross-int. 332. You say in your answer to interrogatory 304 that Exhibit 10 is constructed substantially in accordance with the reissued patent of the complainant; is there any exit-pipe B to said exhibit?

Ans. There is not any exit-pipe upon the side of the annular recess as represented by the nozzle B.

236 Cross-int. 333. How does the projection of the lip of the valve beyond the outer periphery of the steam-pipe in said exhibit compare with the same projection of the lip of the valve in the drawing of said reissued patent?

Ans. It is substantially the same in those parts which affect its operation.

Cross-int. 334. What is the projection of the lip of the valve in said Exhibit 10 beyond the outer periphery of the steam-pipe?

Ans. The inner diameter of the downwardly projecting lip is very nearly, if not quite, one-fourth of an inch larger than the diameter of the outer periphery of the steam-pipe; the projection is therefore one-eighth of an inch.

Cross-int. 335. What is the like projection in figure 1 of complainant's exhibit 1?

Ans. It is the same, as nearly as may be.

Cross-int. 336. How much larger is the valve in Exhibit 10 than in Exhibit 1?

Ans. One inch and one-fourth in its diameter, the steam-passage in Exhibit 10 being two and one-fourth inches, while in Exhibit 1 it is one inch.

Cross-int. 337. In Exhibits 8 and 9 is not the diameter inside the valve-casing three and eleven-sixteenths inches, the nozzle B one and three-fourths inches in diameter, and inside of the steam-pipe and inside of the ground joint two and one-fourth inches? And is not, in Exhibit 1, the diameter of nozzle B substantially of the same size as the diameter inside of the valve-casing, and is not inside the steam-pipe and ground joint one inch in diameter?

Ans. In Exhibits 8 and 9 the diameter of the inside of the valve-casing is very nearly as stated in the question, and all the other dimensions stated in the question are correct, or very nearly so.

Cross-int. 338. In the drawings, Exhibit 1, nozzle B is much larger than the steam-pipe, in Exhibits 8 and 9 much less than the steam-

pipe; where in the specifications do you find directions for so contracting exit-pipe B as is found in Exhibits 8 and 9?

Ans. The exit-pipe B in Exhibits 8 and 9 is not contracted, but is of the same size, or very nearly so, of the nozzle B, shown in the
237 drawing; as to the authority given in the specification for constructing a valve upon this principle, I have quoted the language so often that it does not seem necessary that I should go over with it again. I will say, however, that it is found in that portion of the specification which directs that the valve should be so constructed as to cause a portion of the steam to pass up around the lip of the valve.

Cross-int. 339. While nozzle B, in said drawing and said exhibits, is of substantially the same diameter, is not the diameter of the steam-pipe in Exhibits 8 and 9 two and a quarter inches, while in said drawing it is but one inch?

Ans. It is.

Cross-int. 340. In any of the experiments about which you have testified did any valve make a drumming noise?

Ans. They did not.

Cross-int. 341. Did, in said experiments, any valve open and close a number of times rapidly in succession?

Ans. They did not.

Direct examination resumed:

Int. 342. Have you in your hand the book of Charles H. Haswell, referred to in cross-interrogatory 323? If yes, please produce it.

Ans. I have the book.

(Witness produces the book referred to in the last interrogatory, which complainant puts in evidence, especially that part which has been referred to by the witness in testifying; also the tables of the areas of circles, circumferences of circles, and the rules of computation relating thereto.)

Int. 343. You have stated in answer to cross-interrogatory 332 that there is not any exit-pipe in the side of the annular recess of exhibit 10, as represented by the nozzle B; state whether or not that exhibit contains any equivalent for said nozzle, or any part which performs the same function.

Ans. I think it does contain an equivalent for the nozzle spoken of in the question, and that it is found in the increased annular
238, 239, space outside the lip of the valve which permits the steam to pass into the atmosphere after it has done its work upon the valve; in which case it performs the same function as does the nozzle B, referred to.

Int. 344. State whether or not the area of the inner face of the projecting lip in Exhibits 8, 9, and 10, is proportionally greater than the said area would be in a valve of the size shown in figure 1 of the drawings of the reissued patent.

Ans. I think it is.

Cross-int. 345. What is the width of the opening for the escape of the steam around the lip in Exhibits 8 and 9?

Ans. In Exhibit 8 it is a full sixteenth of an inch; and in Exhibit 9 it is something more than that, the difference in the diameter between the inner surface of the casing and the outer surface of the lip of the valve being fully three-sixteenths of an inch, which difference is due to the thickness of the outer edge of the lip of the valve.

Cross-examination resumed:

Cross-int. 346. Please examine the drawings of Exhibit 1, Exhibit C,

and Exhibit K, being the English Naylor patent, the American Naylor patent, and the reissued patent on which this suit is brought, and state whether there are not in said drawings representations of a number of valves, some of which have the downward curved lip, while others have not; and whether the downward curved lip is found in any instance in said drawings except where the exit-pipe B, which has been termed the "nozzle," is also found.

Ans. I have examined the exhibits referred to and find that there are representations of a number of valves, and that the nozzle B is only found in connection with the valves represented with downwardly curved lips, the others being representations of common safety-valves.

Cross-int. 347. State whether the various areas and circumferences given in your testimony were taken from said book of Charles H. Haswell.

Ans. They were.

JAMES M. BLANCHARD.

Attest: JOHN G. STETSON, *Examiner.*

240, 241 ADDITIONAL EVIDENCE FOR RESPONDENT.

Taken under order of court May 9, 1873, and agreement of parties June 2, 1873, pursuant to the 67th rule of the Supreme Court of the United States, in equity, as amended, before me.

JOHN G. STETSON, *Examiner.*

Second deposition of William C. Hibbard.

JUNE 6, 1873.

Direct examination by Benjamin Dean, esq., of counsel for respondent.

Int. 1. State your name, and whether you have testified before in this case.

Ans. William C. Hibbard. I have already testified in this case.

Int. 2. State how the valve marked "Exhibit No. 3" compares, in construction and mode of operation, with the valve described in the letters patent upon which this suit is brought, and shown in Figs. 1 and 2 of the drawings of said patent.

(Objected to, as incompetent and inadmissible.)

Ans. The Exhibit No. 3 does not conform in any respect which I suppose to be material to this examination to the drawings mentioned in the patent. The valve is not of the same form and proportion of parts and relation of said parts to each other, with the seat for the same, as those parts are represented in the patent, nor the relation of said parts to the passages for the escape of the steam from the valve to the open air. The valve in Exhibit No. 3 has a much larger pro-
242 jection to the lip than is shown in the patent, and it stands in different relation to the ground joint of the valve; and the outer surface of the valve also comes closer to the interior of the casing than is shown in Fig. 1 of the drawings of the patent. But the most important departure from the construction shown in the drawing, and described in the specification of the same, is the construction of a diaphragm about an inch below the top of the valve-seat, which entirely separates the recess below the valve from the lower part of the valve-casing, except by means of seven holes, about three-eighths of an inch in diameter, made through the same. Now these differences in the construction give the valve a character and mode of operation substanially and radically different from the valve described in the patent, and give to the valve a capacity and mode of operation which the valve in the patent

pipe; where in the specifications do you find directions for so contracting exit-pipe B as is found in Exhibits 8 and 9?

Ans. The exit-pipe B in Exhibits 8 and 9 is not contracted, but is of the same size, or very nearly so, of the nozzle B, shown in the
237 drawing; as to the authority given in the specification for constructing a valve upon this principle, I have quoted the language so often that it does not seem necessary that I should go over with it again. I will say, however, that it is found in that portion of the specification which directs that the valve should be so constructed as to cause a portion of the steam to pass up around the lip of the valve.

Cross-int. 339. While nozzle B, in said drawing and said exhibits, is of substantially the same diameter, is not the diameter of the steam-pipe in Exhibits 8 and 9 two and a quarter inches, while in said drawing it is but one inch?

Ans. It is.

Cross-int. 340. In any of the experiments about which you have testified did any valve make a drumming noise?

Ans. They did not.

Cross-int. 341. Did, in said experiments, any valve open and close a number of times rapidly in succession?

Ans. They did not.

Direct examination resumed:

Int. 342. Have you in your hand the book of Charles H. Haswell, referred to in cross-interrogatory 323? If yes, please produce it.

Ans. I have the book.

(Witness produces the book referred to in the last interrogatory, which complainant puts in evidence, especially that part which has been referred to by the witness in testifying; also the tables of the areas of circles, circumferences of circles, and the rules of computation relating thereto.)

Int. 343. You have stated in answer to cross-interrogatory 332 that there is not any exit-pipe in the side of the annular recess of exhibit 10, as represented by the nozzle B; state whether or not that exhibit contains any equivalent for said nozzle, or any part which performs the same function.

Ans. I think it does contain an equivalent for the nozzle spoken of in the question, and that it is found in the increased annular
238, 239, space outside the lip of the valve which permits the steam to pass into the atmosphere after it has done its work upon the valve; in which case it performs the same function as does the nozzle B, referred to.

Int. 344. State whether or not the area of the inner face of the projecting lip in Exhibits 8, 9, and 10, is proportionally greater than the said area would be in a valve of the size shown in figure 1 of the drawings of the reissued patent.

Ans. I think it is.

Cross-int. 345. What is the width of the opening for the escape of the steam around the lip in Exhibits 8 and 9?

Ans. In Exhibit 8 it is a full sixteenth of an inch; and in Exhibit 9 it is something more than that, the difference in the diameter between the inner surface of the casing and the outer surface of the lip of the valve being fully three-sixteenths of an inch, which difference is due to the thickness of the outer edge of the lip of the valve.

Cross-examination resumed:

Cross-int. 346. Please examine the drawings of Exhibit 1, Exhibit C,

and Exhibit K, being the English Naylor patent, the American Naylor patent, and the reissued patent on which this suit is brought, and state whether there are not in said drawings representations of a number of valves, some of which have the downward curved lip, while others have not; and whether the downward curved lip is found in any instance in said drawings except where the exit-pipe B, which has been termed the "nozzle," is also found.

Ans. I have examined the exhibits referred to and find that there are representations of a number of valves, and that the nozzle B is only found in connection with the valves represented with downwardly curved lips, the others being representations of common safety-valves.

Cross-int. 347. State whether the various areas and circumferences given in your testimony were taken from said book of Charles H. Haswell.

Ans. They were.

JAMES M. BLANCHARD.

Attest: JOHN G. STETSON, *Examiner.*

240, 241 ADDITIONAL EVIDENCE FOR RESPONDENT.

Taken under order of court May 9, 1873, and agreement of parties June 2, 1873, pursuant to the 67th rule of the Supreme Court of the United States, in equity, as amended, before me.

JOHN G. STETSON, *Examiner.*

Second deposition of William C. Hibbard.

JUNE 6, 1873.

Direct examination by Benjamin Dean, esq., of counsel for respondent.

Int. 1. State your name, and whether you have testified before in this case.

Ans. William C. Hibbard. I have already testified in this case.

Int. 2. State how the valve marked "Exhibit No. 3" compares, in construction and mode of operation, with the valve described in the letters patent upon which this suit is brought, and shown in Figs. 1 and 2 of the drawings of said patent.

(Objected to, as incompetent and inadmissible.)

Ans. The Exhibit No. 3 does not conform in any respect which I suppose to be material to this examination to the drawings mentioned in the patent. The valve is not of the same form and proportion of parts and relation of said parts to each other, with the seat for the same, as those parts are represented in the patent, nor the relation of said parts to the passages for the escape of the steam from the valve to the open air. The valve in Exhibit No. 3 has a much larger pro-
242 jection to the lip than is shown in the patent, and it stands in different relation to the ground joint of the valve; and the outer surface of the valve also comes closer to the interior of the casing than is shown in Fig. 1 of the drawings of the patent. But the most important departure from the construction shown in the drawing, and described in the specification of the same, is the construction of a diaphragm about an inch below the top of the valve-seat, which entirely separates the recess below the valve from the lower part of the valve-casing, except by means of seven holes, about three-eighths of an inch in diameter, made through the same. Now these differences in the construction give the valve a character and mode of operation substanially and radically different from the valve described in the patent, and give to the valve a capacity and mode of operation which the valve in the patent

does not, in my opinion, possess, even in degree, and that is, the capacity to open suddenly shortly after the steam commences to escape from the valve, and to hold the valve open until the pressure in the boiler is reduced to a degree somewhat below that at which it opened. Now in the description of the Naylor valve, so far as it is given in the specification and shown in the drawings, it is not indicated in any way that the valve was designed to have any such capacity, but only that the steam, as it escaped from the joint of the valve by impinging upon a projecting lip attached to the same, should aid somewhat in overcoming the tension of the spring which held the valve to its seat. But it was not intended, apparently, that it should have the capacity of opening widely at the same pressure of steam, and holding it open until the pressure of the steam was reduced below the point at which the valve opened, against the rapidly increasing tension of the spring which held it, because that was provided for in a measure by another part of the apparatus. But in the Exhibit No. 3 the power which in the Richardson valve is produced for the purpose of opening the valve by means of the employment of the stricture, so called, which prevents the free escape of the steam after it has passed the ground joint, and thus produces a static pressure of the steam within that stricture, and acts against the under side of the lip, is, by the modifications which I have mentioned,
produced in Exhibit No. 3, the diaphragm with the holes in it,
243 and the narrow opening between the valve and the valve-casing
acting as a stricture to prevent the free escape of the steam from beneath the lip of the valve. Now the use of this stricture in connection with the overhanging lip is, in my judgment, absolutely indispensable to making a valve operate in the way I have mentioned, that is, to open widely against the increased tension of the spring, and to remain open until the pressure of the steam is reduced to a point below that at which it opened. And I have no doubt that with a valve constructed like Exhibit No. 3, when placed upon a boiler generating steam rapidly, or discharging a large volume of steam, the pressure above the diaphragm and below the lip of the valve would be considerable, and have the effect to open the valve widely against the pressure of the spring bearing directly upon it. Now in the Naylor patent there is not, in my judgment, any grounds for pretending that such a part as the diaphragm, or anything equivalent to it, even in degree, is to be found in it, nor was there any occasion, with the arrangement of spring shown in the Naylor patent in connection with the bent lever, for the use of any such property in that valve. In order to be able more readily to compare the construction of Exhibit No. 3 with the Naylor patent, I have caused a sectional drawing to be made of the same, showing the construction and relative position of the valve and its seat, and the casing and the diaphragm, and also a plan of the same, which I have now before me, which I believe to be made with perfect accuracy.

(The sheet containing the drawing above referred to is offered in evidence, and marked "Exhibit Hibbard Drawing, J. G. S., Examiner.")

Int. 3. State how the valves marked "Exhibits 4, 8, 9, and 10" compare in construction and mode of operation with the valve described in said specification, and shown in Figs. 1 and 2 of the drawings of said patent.

(Objected to as above.)

Ans. There are some of them that conform as to the shape of the valve and seat and their relations to each other to the drawings in the
patent, as is obvious upon comparison of the drawings which repre-
244 sent them respectively upon the sheet Hibbard Drawing with the

drawings of the patent. On said sheet the several figures which represent the several exhibits are marked as such.

Int. 4. Can you state how a valve constructed according to letters patent granted to Charles Beyer, being defendant's exhibit A, compares in its mode of operation with a valve constructed according to the specification and letters patent on which this suit is brought and shown in Figs. 1 and 2 of the drawings of said patent? And, if yes, state your means of knowledge.

(Same objection, and also because this witness has already been examined by the defendant's counsel in the deposition heretofore given by him in this case in reference to this subject.)

Ans. I have some knowledge in relation to the operation of said valve as compared with that of the Naylor valve, which I have received since I was formerly examined in this case. It is derived from experiments with the two valves now before me, one of which is the Naylor valve, made with its valve and casing accurately according to the drawings of the Naylor patent, and of the same size lineally, but the valve is held down by a direct spring instead of the lever and spring shown in the patent; the other is a Beyer valve made accurately to the form and size of that shown in the patent except the exterior of the hood, and also made with a direct spring instead of the mechanism shown in Beyer's patent. The Naylor model was provided with tubes, one communicating with the under surface of the lip of the valve, and the other with the space in the casing, at a little distance below the lip, and these tubes were connected by flexible tubes with common pressure-gauges. In the Beyer model-pipes were provided, one communicating with the under side of the lip connected with the valve, another communicating with the upper side of the lower lip attached to the seat, and a third communicating with the interior of the hood or casing in which the valve is placed. I saw both these valves subjected to the action of steam by being attached to a boiler. The Naylor valve, in its action as a safety-valve, operated like the common safety-valve, without any appreciable difference practically. The experiments showed the pressures at the several places mentioned to be this: The valve commenced to blow at 80 lbs. pressure, and was made to
245 increase gradually. At the commencement the steam was all discharged upward, and I believe continued to escape upward till the pressure was about 85 lbs., with an increased volume of discharge, when the steam escaped from the valve-casing in both ways, that is, some of it upward past the valve, and some of it downward and escaped at the branch pipe. When the pressure had increased to 90 lbs., with a large escape of steam, it all escaped below, with a draft downward between the valve and the casing. In this condition the pressure against the under surface of the lip of the valve, as indicated by pressure-gauge attached to the pipe leading to that place, indicated from seven and a half to eight pounds pressure, and by the gauge communicating with the space below the lip about two and a half pounds vacuum. There was no sudden rising of the valve, or "pop," as it is called, and there was no reduction of the pressure in the boiler by its action. With the Beyer valve put in the same place, it commenced to blow off steam slightly at 80 lbs.; and in one instance, when the pressure had increased to 85, the valve "popped" when the pipe communicating with the upper lip showed a pressure of 8 or 9 lbs. at its greatest height, varying from that to less, and the pressure on the lower lip showed a vacuum of from two to three pounds. These pressures in al cases were probably modified by the action of the current of steam

flowing past the orifices, and probably do not show accurately the exact pressure that exists between the surfaces throughout, but they show clearly this, that the lips in both valves, so far as regards the impact of the steam upon them, act in substantially the same way. And although in the Beyer valve the opening between the lip and seat at its outer extremity is somewhat narrower than it is near the ground joint, it does not appear to be enough, nor the chamber within the stricture large enough to act as the valve and stricture act in opening the valve suddenly and holding it open so wide as to reduce the pressure in the boiler below the point at which it opened. In another experiment the valve commenced to blow at 80 lbs.. the pressure rose to 85 lbs., when the valve commenced to chatter; it did not "pop," and stopped blowing when the pressure was reduced to 77 lbs. In that case the press-
246 ure at the upper lip was 2 lbs., and at the lower lip it was 2 lbs. vacuum. The action of the valve does not appear to be very uniform, but varies with the rapidity with which the steam is generated. In the first experiment with this valve the steam was generated more rapidly than in the last one. The pressure inside the hood, or casing, was also tried and found to be zero, which was determined by a gauge attached to the opening to that part.

(The valves referred to by the witness are marked "Exhibit Hibbard, Naylor Model, J. G. S., Examiner," and "Exhibit Hibbard, Beyer Model, J. G. S., Examiner," respectively.)

Int. 5. Look at Complainant's Exhibit 6, and state whether a gauge on the generator would correctly indicate the pressure on a valve placed on the pipe as there represented, at about seven feet from its connection with the generator, while steam was being discharged at the valve.

Ans. It would not; the gauge would indicate a higher pressure than there was at the valve, the amount depending upon the rapidity with which the steam was discharged as compared with the area of the pipe; the greater the amount of discharge the greater would be the difference in pressure at the valve, as compared with that in the boiler.

(No cross-examination.)

W'M C. HIBBARD.

Attest: JOHN G. STETSON, *Examiner.*

JUNE 13, 1873.

Present: James B. Robb, esq., of counsel for complainant; Benjamin Dean, esq., of counsel for respondent.

And now, before me, as examiner in the suit of Edward H. Ashcroft v. The Boston and Lowell Railroad Company, comes Benjamin
247 Dean, counsel for the said defendant, and says that the defendant wishes to use in said case the testimony of Hervey Waters, taken in the suit of George W. Richardson v. Edward H. Ashcroft, pending in this court, and designates said testimony as testimony he wishes to use in this suit under a stipulation filed January 3, 1873.

(Objected to by counsel for complainant as not admissible under the stipulation referred to, the testimony of M'r Waters being incompetent and inadmissible as evidence for any proper purpose in the case in which it is taken.)

Attest:

JOHN G. STETSON, *Examiner.*

ADDITIONAL EVIDENCE FOR COMPLAINANT.

Offered de bene esse in reply, under order of court, May 9, 1873, before me.

JOHN G. STETSON, *Examiner.*

Deposition of William J. Cambridge.

BOSTON, *September* 18, 1873.

Direct examination by James B. Robb, esq., of counsel for complainant.

Int. 1. Please state your name, age, residence, and occupation.

Ans. William J. Cambridge; twenty-seven; Boston, Mass.; draughtsman.

Int. 2. With whom have you been engaged as draughtsman, and how long?

Ans. Teschemacher & Stearns; I have been at work for them about ten years, and have been draughtsman about nine.

Int. 3. Have you witnessed the practical or experimental working of what is called the Beyer valve, marked "Complainant's Exhibit Cambridge, Beyer Valve, J. G. S., Examiner," now before you? If yea, please state when and where, and what observations you made.

248 Ans. I have, at M'r Ashcroft's place of business, in Sudbury street. The first experiment I made was Sept. 9, 1873. I also made another trial the 15th of the same month with the same valve. At the trial of the Beyer valve, Sept. 9th, I allowed the steam to enter the valve at a pressure of 63 pounds, and allowed it to rise to 80 pounds, when I shut off steam. I then measured the lift of the valve, which was 1-32d of an inch. The time of raising the steam from 63 to 80 pounds was ten minutes. I then made a second trial of this same valve, right afterwards, by allowing the steam to enter at 60 pounds pressure and run to 80 pounds, when I shut off steam and measured the lift of the valve, which was 1-32d of an inch. We were nine minutes and a half running on this trial. Both these trials were made on a branch pipe; the valve was not placed on a boiler. On the 15th of September I again tried the Beyer valve, starting the steam at 55 pounds pressure and running to 73 pounds, when I shut off steam and measured the rise of the valve, which was 1-32d of an inch. The time of running was ten minutes.

Int. 4. Have you also witnessed the practical or experimental working of the Naylor valve now before you and marked "Complainant's Exhibit Cambridge, Naylor Valve, J. G. S., Examiner"? If so, state when, where, and what observations you made.

Ans. I have, at the same place, on the 10th and 15th of September, 1873. On the 10th inst. I tried the Naylor valve on the boiler with steam at 61½ pounds; it rose to 64 pounds and popped and fell to 60½ pounds. I then placed the valve on a branch pipe leading from the same boiler, represented at *a a* on Complainant's Exhibit 6, at that part of the pipe where the valve is shown between *a a*, and allowed the steam to enter at 61½, and it rose to 64½ and popped and fell to 61. I then measured the lift of the valve, which was an eighth of an inch short. On the 15th inst. I again made another trial on this same branch pipe, and the valve commenced to lift at 63, and rose to 67¼, when it popped and fell to 63. I then had the valve placed on the boiler, and the valve commenced to lift at 63¼, and rose to 67, and pop-

ped and fell to 62½, when it closed. I then made another trial on
249 the branch pipe; it commenced to lift at 63 and rose to 68 pounds, and popped and fell to 63 pounds and closed. I measured the lift of the valve, which was an eighth of an inch short.

Int. 5. Where was the steam-gauge located during all those experiments about which you have testified?

Ans. It was on the boiler of the right-hand front end.

Int. 6. Have you a drawing of those valves? If so, please produce it, with such explanations as are necessary to the understanding of that drawing.

Ans. I have, and produce it. At the first trials of the Beyer valve, Sept. 9th trials, the valve was made as shown at Fig. 2, and when shown to counsel for complainant he said that the valve was not made right, and suggested that the valve be altered to conform to the valve shown in patent papers, the Beyer patent, which alterations were made, and the September 15th trials were made with the altered Exhibit Cambridge, Beyer valve, and as shown in Fig. 3. The valve shown at Fig. 4 conforms to Complainant's Exhibit Cambridge, Naylor Valve.

(Drawing produced is marked "Complainant's Exhibit Cambridge, Drawing, J. G. S., Examiner.")

Cross-examination (de bene esse) by Benjamin Dean, esq., of counsel for defendant:

Cross-int. 7. Have you testified to all the experiments you were called upon to witness at M'r Ashcroft's shop?

Ans. No, sir.

Cross-int. 8. What other experiments were you called upon to witness?

Ans. The trial of the Richardson valve.

Cross-int. 9. When?

Ans. Sept. 9th and 15th, 1873.

Cross-int. 10. Were you called upon to witness experiments on any other valves?

Ans. No, sir.

250 Cross-int. 11. Did you witness any other experiments than you have testified to on the Beyer and Naylor valves here present?

Ans. I did not.

Cross-int. 12. Then you merely went to M'r Ashcroft's shop to witness such experiments as might be shown you for the purpose of testifying thereto, did you?

Ans. Yes, sir.

Cross-int. 13. Who turned off the steam when it was turned off in those experiments?

Ans. I did.

Cross-int. 14. What time of day were those experiments tried?

Ans. Between 9 and 11 o'clock a. m.

Cross-int. 15. Was the engine running?

Ans. Yes, sir.

Cross-int. 16. What persons were present?

Ans. There were two parties present, but I don't know the names of either of them, and part of the time M'r Ashcroft stood one side.

(Witness here states that the experiments made with the Beyer valve, to which he has testified, were made with the hood marked "Complainant's Exhibit Cambridge, Beyer Valve Hood, J. G. S., Examiner.")

W'M J. CAMBRIDGE.

Attest: JOHN G. STETSON, *Examiner.*

251 **The following is the testimony of Hervey Waters, taken in the suit of George W. Richardson v. Edward H. Ashcroft, pending in the said circuit court of the United States, district of Massachusetts, and designated before John G. Stetson, examiner in this cause, on the thirteenth day of June, 1873, by Benjamin Dean, esq., counsel for said Boston and Lowell Railroad Company, defendant, as testimony which the said defendant wished to use in this cause, under the stipulation filed Jan. 3, 1873, namely:**

Circuit court of the United States, district of Massachusetts.

GEORGE W. RICHARDSON, COMPLAINANT,
v.
EDWARD H. ASHCROFT, DEFENDANT. } In equity.

252 EVIDENCE FOR COMPLAINANT.

Taken pursuant to the sixty-seventh rule of the Supreme Court of the United States in equity, as amended, before me.

C. W. TUTTLE,
Examiner.

Deposition of Hervey Waters.

APRIL 4, 1871.

Direct examination by Benjamin Dean, esq., of counsel for complainant:

Int. 1. State your name, age, residence, and occupation.

Ans. My name is Hervey Waters; age, sixty-seven years; reside in Boston. I am a machinist.

Int. 2. Please state your experience as an expert in patent causes.

Ans. I have had considerable experience as an expert in the United States court, for something over twenty years last past.

Int. 3. Have you examined, and with what care, a copy of the letters patent of the United States to George W. Richardson, dated the 25th of September, 1866, No. 58294, here put in, and marked "Exhibit B, C. W. T., Ex'r," and do you understand the same, and the mode of operation of the valve therein described?

Ans. I have, with considerable care, and I understand the mode of operation of the valve therein described.

Int. 4. Please look at Exhibit A, and state how said exhibit compares with the valve described in said letters patent.

(The defendant admits that he has sold valves like Exhibit A before the commencement of this suit.)

Ans. It is the same valve in construction and mode of operation as that described in the Richardson patent. It will, however, be observed that there is an appendage attached to the valve-seat, Exhibit A, consisting of a ring or curved lip for the purpose of giving the steam a cast upward after it escapes from the valve, which is not found in the Richardson patent. There are, also, two lugs at the top of the valve
253 in Exhibit A, which I understand to be for the purpose of grinding the valve to the seat, which are not found in the patent; but these lugs have nothing to do with the operation of the valve for its purpose. It also appears to me that in Exhibit A, the lip which extends over the valve-seat extends downward below the top of the valve-seat

rather farther than is described in the patent; but these differences do not go to change the character of the contrivance. The valves and valve-seats are substantially the same in all respects in the Exhibit A and in the letters patent, and are of the same dimensions, almost exactly.

(No cross-examination.)

HERVEY WATERS.

254 EVIDENCE FOR COMPLAINANT, IN REPLY.

Taken pursuant to the sixty-seventh rule of the Supreme Court of the United States in equity, as amended, before me.

JOHN G. STETSON, *Examiner.*

Deposition of Hervey Waters.

JUNE 12, 1873.

Direct examination by Benjamin Dean, esq., of counsel for complainant.

Int. 1. State your name, and whether you have testified before in this case.

Ans. Hervey Waters, and I have before testified in this case.

Int. 2. Have you examined reissued letters patent No. 3727, granted Edward H. Ashcroft, Nov. 9, 1869, as assignee of William Naylor, and marked "Exhibit Naylor, Reissue, J. G. S., Examiner;" and do you understand the construction and mode of operation of the valve or valves therein set forth and shown?

Ans. I have; and I do.

Int. 3. State how the valve, Exhibit A, compares in construction and mode of operation with the valve described in said specification, and shown in Fig's 1 and 2 of the drawings of said patent.

Ans. The valve, Exhibit A, is a Richardson valve, precisely such as is described in the letters patent to Richardson, upon which this suit was brought; and this valve has upon it, outside of the valve-seat proper, a lip projecting beyond the seat against which the steam escaping through the seat of the valve after it is lifted therefrom impignes, and this jet of steam, as it impignes against the extended lip of the valve, is made directly available in causing an increased pressure on the valve, and thus overcoming the increased resistance of the spring due to its compression. Now, this same feature is found in the valve described in the Naylor patent, and represented in the drawings of Fig's 1
255 and 2; but the lip in the Naylor valve is different in form from the lip in the Richardson valve, and has a different relation to the valve-seat proper, so that in the Richardson valve the lifting force of the jet will be much greater than it will in the Naylor valve, everything else being equal. There are no other similarities in the two things inquired of that are important to a proper understanding of the matter here in issue, so far as I know.

Int. 4. Have you examined the English specification of William Naylor, A. D. 1863, No. 1830, marked "Exhibit C, J. G. S., Examiner"? And if so, state how the valve, Exhibit A, compares in construction and mode of operation with the valve described in said specifications and the drawings, Fig's 1, 2, 5, and 6, thereto annexed.

Ans. I have examined the patent inquired of and find described therein, and represented at the drawings, Fig's 1, 2, 5, and 6, the same contrivance as that referred to in the reissue to Ashcroft at Fig's 1 and

2, and therefore I make the same comparison as I made to answer to interrogatory 3.

Int. 5. Please state whether you find in either of said Exhibits Naylor Reissue, or C, the invention described in the patent on which this suit is brought.

Ans. I do not.

Int. 6. Do you find any substantial and material differences between the construction and mode of operation of the valve described in the letters patent on which this suit is brought, and the construction and mode of operation of the valve described in Exhibits Naylor Reissue and C? If yes, please state them.

Ans. I find a substantial and material difference between the two contrivances inquired of. The Richardson valve, described in this patent, is so constructed and arranged as to have the steam escaping from the valve proper act by its expansion force against the lip which I have before mentioned against which the steam impinges to assist in raising the valve and to overcome the pressure of the spring, nothing of which is found in the Naylor contrivance. The patent says: "The value of my invention consists in increasing the area of the head of the common safety-valve outside of its ground joint, and terminating it in such a way as to form an increased resisting surface against which the steam escaping from the generator shall act with additional force after
256 it has lifted the valve from its seat at the ground joint; and so, by overcoming the rapidly-increased resistance of the spring or scales, ensure the lifting of the valve still higher, thus affording so certain and free a passage for the steam to escape as effectually to prevent the bursting of the boiler or generator, even when the steam is shut off and the damper left open." Further on the patent says: "I terminate this addition to the head of the valve with a circular or annular flange, or lip *c c*, which project beyond the valve-seal E E, Fig. 3, and extends slightly below its outer edge, fitting loosely around it and forming the circular or annular chamber D D, whose transverse section, shown in the figure, may be of any desirable form or size. This flange, or lip *c c*, fitting loosely around the valve-seat E E, is separated from it by about one sixty-fourth of an inch for an ordinary spring or balance. For a strong spring or balance, this space should be diminished; and for a weak spring or balance, it should be increased to regulate the escape of the steam, as required."

Further on the patent again says: "With my improved safety-valve, constructed as now described, and attached to the generator in the usual way, the steam escaping in the direction indicated by the arrows in Fig. 3, first lifts the valve from its seat at the ground joint E F, and then passing into the annular chamber D D, acts against the increased surface of the valve-head, and by this means, together with its reaction produced by being thrown down upon the valve-seat E E, it overcomes the rapidly-increasing resistance of the spring or balance, lifts the valve still higher and escapes freely into the open air until the pressure in the generator is reduced to the degree desired, when the valve will be immediately closed by the tension of the spring or balance."

Considering all that is referred to in the quotations above made, as to the construction and mode of operation of this Richardson valve, I find nothing of it in the Naylor patent, except so much as I have before stated concerning the impinging of the jet of steam against this extended surface. For it should be understood that there are in this Richardson valve two important features, to wit: First, a peculiar stricture by means of which the steam escaping from the valve proper, is made to act by its

expansive force upon an additional area outside of the valve proper (but practically integral therewith) to assist in raising the valve; this structure being so constructed and combined with the valve as to be
257 enlarged when the valve is considerably lifted from its seat; and it is to this peculiar stricture and its mode of operation in connection with the chamber that I understand the patent more particularly refers in the quotations which I have made from it.

Second. The peculiar construction and arrangement of the aforesaid additional arm or lip in relation to the valve proper, so that the impinging force of the jet of steam escaping through the valve proper is made of direct utility in lifting the valve.

Int. 7. You say, in your last answer, that the Richardson valve described in his patent, is so constructed and arranged as to have the steam escaping from the valve proper act by its expansive force against the lip, which you have before mentioned as the lip against which the steam impinged; and you also say that you find nothing of that in the Naylor contrivance. Upon what do you form and express that opinion?

Ans. Upon actual experiment with the valve before me marked "Exhibit Hibbard, Naylor Model, J. G. S., Examiner." This exhibit was made at my suggestion, I believe, and it was made for the purpose of testing the mode of operation of the Naylor valve, such as is referred to in Fig's 1 and 2, such as is referred to in the reissued patent to Ashcroft, and the instructions were to make it exactly like the drawings as near as possible, and I believe it is so made, and with this valve so made experiments were tried as follows:

Into the lip of the valve was inserted a small tube, as will be seen by reference to the exhibit, and into the casing of the steam aperture or passage-way, or as the reissue patent describes it in the second claim thereof, annular recess D, another tube was inserted, as will also be seen in the exhibit. To each of these tubes was connected a flexible rubber tube, which was connected to steam-gauge, both of which steam-gauges I saw tested so as to prove their relative accuracy, and altogether they were so arranged as to indicate the pressure of the steam upon the lip, with one gauge, and the pressure of the steam within the recess upon the other gauge, and the spring which keeps down the valve was screwed down to such tension as to allow the steam to lift it slightly when the pressure in the steam-generator was about eighty pounds to the square inch, I believe. When the Naylor valve first began to blow on this pressure it acted the same as a common safety-valve, showing no perceptible pressure by the impinging force of the escaping steam
258 upon the lip, or a very little pressure; and like the common safety-valve, it does not prevent the steam-generator from going on to increase the pressure. When the pressure was increased to about eighty-six pounds to the square inch in the generator, the pressure indicated upon the gauge upon the lip by the impinging force of the steam was about two and a half pounds to the square inch, the gauge upon the recess at the same time indicating about a half pound less than nothing, as compared with the pressure of the atmosphere, showing there was no pressure upon the lip by the expansive force of the steam; but on the contrary that there was a tendency to a vacuum of about half a pound to a square inch, and that, so far as the expansive force of the steam was concerned, there was nothing accomplished towards lifting the valve against the pressure of the spring, so that the pressure of the atmosphere was greater above the lip than below it by this half pound to the square inch. This tendency to a vacuum was in consequence of the di-

rection to the jet of steam by the curve of the lip, causing it to rush down upon the outer wall of the recess, and out through the steam-discharging aperture, and by its friction upon the air in the recess, taking it along and driving it out at the steam-discharging orifice, thus ejecting the air through the steam-discharging orifice similar to what is done with the Jeffard injector for feeding steam-boilers when it is used as an ejector to drive out the air and form a vacuum so as to draw up water from below to be afterwards driven into steam-boilers by a similar jet of steam; as a consequence of this action of the jet of steam upon the air, so as to produce greater pressure of the atmosphere above the valve than below it, there was a rush of air from above the lip downward between the outer casing of this recess and the outer periphery of the lip of the valve, the same as there will be a rush of air whenever the equilibrium of the pressure of the atmosphere is disturbed; but with the Naylor contrivance, acting as I have just described, the boiler was not relieved essentially more than it would be with a common safety-valve, the pressure within the boiler still increasing until the gauge indicated ninety pounds to the square inch. When the gauge indicated ninety pounds to the square inch, as before stated, as the pressure within the boiler, the gauge connected with the lip of the valve indicated a pressure of about eighty pounds to the inch, and the gauge connected with
259 the recess or steam passage, indicated a tendency to a vacuum of about one and one-half pounds to the square inch, according to my minutes; and when the pressure within the boiler had gone to about ninety-two pounds to the square inch, as I have it, the valve hung, by which I mean that the escape of steam was equal to the generating power of the fire, so that the greater pressure was reached; all of which proves clearly that there is no pressure below the lip in the Naylor valve, due to the expansive force of the steam, but only the pressure due to the impinging force of the steam upon the lip.

The steam in the boiler was then reduced by means other than the valve, until the valve closed and stopped blowing, which took place after the steam had been so reduced, and at a point when the gauge indicated a pressure of seventy-two pounds to the square inch within the boiler.

Some other similar experiments were afterwards tried with the same valve, with results varying slightly from what I have above stated, but showing and maintaining the same general character of the valve.

Int. 8. In any stage of these experiments did any portion of the steam pass upward around the lip of the valve?

Ans. Yes; when the valve first began to blow it all passed up around the lip of the valve.

Int. 9. Were any experiments made with the Richardson valve; and, if yes, what was the operation of said valve as compared with the operation of the Naylor valve which you have described?

Ans. I have seen several experiments with the Richardson valve, and among others an experiment similar to what I have already described as having been tried with the Naylor valve; that is to say, having a steam-gauge connected with the lip of the Richardson valve, the same as was done with the lip of the Naylor valve in the experiment just described, and another gauge connected with what is called in the Richardson valve a circular or annular chamber D D, into which the steam immediately passes when the valve lifts from its seat, similar to what was done with the steam-passage or recess in the Naylor valve.

In making this experiment, the two steam-gauges were tested as to

their uniformity of action, and they were the same two steam gauges that were used in the experiments on the Naylor valve.

The steam generator was a locomotive-boiler capable of mak-
260 ing steam rapidly, as locomotive-boilers usually are, and capable of making steam much more rapidly than the boiler upon which the Naylor experiments were tried, as before related by me.

The spring which keeps down the valve to its seat was screwed to a pressure such as would allow the valve to open when the gauge upon the steam-generator indicated 100 pounds pressure to the square inch.

Now, the first differences which should be noticed, in my judgment, between the Naylor valve and the Richardson valve, are the practical results of the two valves for the purpose of relieving the boiler.

With the Richardson valve, and with a good fire in the boiler, so as to generate steam rapidly, as a locomotive must do in drawing a heavy train or a fast train, when the valve opened the boiler was immediately relieved, there being no increased pressure within the boiler after the valve opened; but there was an immediate reduction of the steam, so that the valve closed again in about twenty seconds of time after the valve first opened, the pressure within the boiler being reduced five pounds for that purpose when the valve closed. This was the result of several experiments with the Richardson valve, which was tried in connection with the steam-gauges upon and under the lip, as I shall further describe; but in other experiments which I have seen tried with the Richardson valve, it will close with a reduction of two and a quarter pounds to the square inch, and any good Richardson valve which is in good order will do that.

Another practical difference between the two valves under consideration, consists in the facts that with the Richardson valve, immediately upon its opening under pressure of the steam, it opens to its full capacity, while the Naylor valve opens gradually like a common safety-valve, and the Richardson valve in closing, closes gradually for a short time and for a short space until the pressure is reduced, as I have before stated; then it closes abruptly and tightly without wire-drawing the steam, while in the Naylor valve it closes gradually from first to last, wire-drawing the steam the whole time.

These practical differences are of great importance, especially upon locomotive-engines, and more especially those locomotives which are used to draw express trains and other passenger-trains, where the steam-generative qualties of the machine are put to the greatest capacity
while running, and then make sudden stops with the fires still
261 running at their utmost capacity, so as to be ready to start again from the station with the full capacity of the machine, and where, as a consequence of the peculiar character of the locomotive, and as a necessity, the steam-chambers within the boilers must be small compared with its steam-generating qualities, and altogether so that the boilers must be readily and quickly relieved by the safety-valves upon them so as to prevent the disastrous consequences that have frequently happened with the old safety-valves, but for the details of the experiments.

When the Richardson valve was tried, as before stated, and instantaneously upon the opening of the valve, the pressure of the steam upon the extended lip, as indicated by the steam-gauge, was thirty to forty pounds to the square inch, the extreme movement of the index of the steam-gauge being so sudden as to make it difficult to follow it with the eye, so as to tell exactly how far it did reach; but it went somewhere to from thirty to forty pounds upon the dial of the gauge.

The index upon the other gauge connected with the chamber acted in a similar manner, but reached no farther than to somewhere between fifteen and twenty pounds upon the dial of the steam-gauge. The index upon either gauge then receded immediately and rapidly from the extreme point reached for some distance, going back gradually as the pressure is decreased in the boiler, and gradually approaching the same relative pressure as indicated above and below the lip, until both gauges indicated a pressure of about five pounds, when the valve immediately closes. Now from those experiments I understand that the differences between the pressure indicated upon the upper lip and the pressure indicated upon the lower lip will always represent substantially the impinging force due to the jet of steam upon the lip of the Richardson valve, while the pressure indicates by the gauge attached to the chamber of the valve indicates the pressure upon the lip of the valve due to the expansive force of the steam independent of the impinging force of the jet, both acting together to overcome the pressure of the spring and to open the valve in the Richardson contrivance, and the steam-gauge connected with the lip indicating the sum of the two forces so acting upon the lip.

Int. 10. You say in your answer to the sixth interrogatory, speaking of what you call the peculiar structure of the Richardson valve, that said stricture is so constructed as to be enlarged when the valve
262 is considerably lifted from its seat. Do you find anything corresponding to that feature of the Richardson valve in any of the contrivances described in the Naylor patent?

Ans. No; I do not. I do not understand that it has been alleged that there is any such stricture above described in the Naylor patent than as is referred to in Figs. 1 and 2 of the Naylor patent, and there is certainly no such stricture in that, nor is there any stricture acting in any way as the stricture acts in the Richardson contrivance.

Int. 11. Have you examined the English letters patent granted to Charles Beyer, No. 1038, sealed Oct. 16, 1863, for improvements in safety-valves, being marked "Exhibit A, C. W. T., Examiner," in another cause, and now identified by the initials J. G. S., Examiner? If so, state whether you understand the construction and mode of operation of the valve or the valves therein set forth and shown.

Ans. I have examined the English letters patent inquired of, and understand the construction and operation of the valves therein described.

Int. 12. State how the valve therein described compares in construction and mode of operation with the valve described in the letters patent on which this suit is brought.

Ans. The valve therein described, or so much of it as is pertinent to this controversy, as represented by the exhibit before me, marked "Exhibit Hibbard Beyer Model, J. G. S., Examiner," and is in its mode of operation, and for all the purposes of a safety-valve, substantially the same as the Naylor valve represented by the model Exhibit Hibbard Naylor Model. There is, however, upon this Beyer valve a lip extending out from the valve-seat, which is not found in the Naylor patent, and which lip, as it appears from the patent, was intended to assist in some way the action of the steam upon the lip extending from the valve itself, and which is immediately over the lip extending from the valve-seat. But this model of the Beyer valve was made, I believe, at my suggestion and by my instructions, the instructions being to make it as near as possible like what is described in the patent, and including the hood which goes over and encloses the valve, so as to see by the experi-

ment what was the mode of operation of the valve described by Beyer and including the hood, but leaving out so much of all that is described in the Beyer patent as was intended by him to assist in closing
263 the valve after it had been opened by the direct action of the steam upon the valve. This Beyer valve here before me, which is constructed according to the Beyer patent, as I have already described, has, as will be seen, tubes entering into it, one into the upper lip of the valve, which is attached to the valve proper, another into the under lip, which is upon the valve-seat, and another into the hood, so as to test experimentally the pressure upon each of the parts by steam-gauges after the manner described by me when speaking of the tests of the Naylor patent experimentally.

This Beyer valve, as it stands here, I saw tested in the same position and under substantially-the same circumstances as I saw the Naylor valve tested as I have before described. I found the result substantially the same with the Beyer valve as with the Naylor valve, so far as there was any pressure by the escaping steam which was availed of for the purpose of overcoming the force of the spring which holds the valve to its seat. There was some variation in the figures and some variation in the action of the valve, but nothing of importance which went to vary the substantial character of the two valves for the purposes of relieving a boiler from undue pressure of the steam. When considerable steam escaped from the valve, the impinging force of the steam produced a pressure upon the lip, tending to open the valve, substantially in the same manner, and very nearly to the same extent, under the same circumstances as is done in the Naylor valve; and the gauge attached to the under lip, which extends out from the valve in the Beyer patent, indicated substantially the same result as was indicated by the gauge attached to the the chamber in the recess in the passage-way in the Naylor patent, showing a tendency to a vacuum in that lip, the same as in the Naylor patent, but to something of a larger degree, as well as I remember. The gauge when connected with the hood in this Beyer valve showed that there was no pressure within the hood due to the escaping steam through the hood and out of the exit-pipe. So this Beyer valve differs from the Richardson valve, for all practical purposes, substantially the same as the Naylor valve does, as I have before described in comparing the Naylor valve with the Richardson valve.

Int. 13. Look at copy of letters patent No. 10243, granted Henry Waterman Nov. 15, 1853, for improvement in safety-valves for locomotive engines, and the certificate of extension thereof, marked in another
264 case "Exhibit D, C. W. T., Examiner," and now marked for identification by the initials of "J. G. S., Examiner," and the reissue thereof marked in said other case "Exhibit E, C. W. T., Examiner," and now marked for identification by the initials "J. G. S., Examiner," and state whether you understand the construction and mode of operation of the valve or valves therein described; and, if yes, state how said valve or valves compare in construction and mode of operation with the valve described in the letters patent on which this suit is brought.

Ans. I have examined the patents inquired of and understand the contrivance therein described, more especially so much of the same as relates to this controversy, and which consists in the valve itself with its extended surface, and with the stricture connected therewith when the same is used in connection with a spring only for holding the valve to its seat, as now universally practised, so far as I know, with the valves of locomotive engines.

This valve of Waterman contained one, and the first one mentioned,

of the important features which I have said were contained in the Richardson valve. It has the stricture acting very much like what is described in the Richardson patent, which serves to enable the escaping steam to act by its expansive force upon the extended arm of the valve, so as to assist in overcoming the pressure of the spring; but it does not contain the other feature of the Richardson valve, by which the escaping jet of steam is made to act by its impinging force upon the extended arm of the valve, so as to be of direct utility in overcoming the pressure of the spring. And in consequence of this difference between the Waterman valve and the Richardson valve, the Waterman valve is short-lived, as compared with the Richardson valve, because that the escaping steam passes through the stricture of the Waterman valve much more rapidly than it passes through the stricture of the Richardson valve, when the pressure within the boiler is the same in both cases, and therefore any oxide, or any other fine grinding material, carried out by and with the steam as it escapes from the valve, cuts away the corners upon the Waterman valve and destroys their utility in connection with the stricture much sooner than is done in the Richardson valve.

I have seen some experiments with a Waterman valve fitted with a pipe in the extended portion of the valve and another pipe in the casing around the seat of the valve (which casing extends up and in con-
265 nection with the extended portion of the valve forms the stricture), communicating with the chamber of the valve, which pipes were furnished with steam-gauges after the manner practised in the experiments upon the Naylor and the Richardson valves, which I have before described, and the results of those experiments were as follows:

When the valve-spring was screwed down so as to allow the valve to blow off at a pressure of eighty-five pounds to the square inch by the steam-gauge, and the valve opened at that pressure, the immediate effect of the pressure of the steam upon the extended portion of the valve was fifty-five pounds nearly, and the pressure upon the other steam-gauge connected with the chamber reached eighty-five pounds, which was equal to the pressure inside the boiler. So that it will be seen that with the Waterman valve the maximum pressure was at the lower pipe, communicating with the chamber, while in the Richardson valve the maximum pressure was at the upper pipe, communicating with the extended lip of the valve. And besides the impinging force of the steam which was marked by the gauge indicating eighty-five pounds, was expended against the walls which surround the chamber in the Waterman, instead of against the extended lip as in the Richardson, so that the impinging force of the steam was of no direct utility in the Waterman for the purpose of raising the valve, while it is of direct utility to a very important degree in the Richardson contrivance. Moreover, it is only the fifty-five pounds indicated by the gauge connected with the extended portion of the valve which goes to assist in overcoming the pressure of the spring, and this is mainly by the expansive force of the steam acting within the chamber, so that in this case the whole force acting to assist in raising the valve by its extended portion is indicated by the gauge connected with the extended portion of the valve, and is due mainly to the expansive force, as I have before stated.

Now I have said that the steam escapes through the stricture in the Waterman valve more rapidly than in the Richardson valve, and I gather this fact from the difference of pressure in the chamber of the two valves; and I understand this pressure to be indicated by the expansive force of the steam within the chamber in the Richardson valve independent of the impinging force of the steam which in the Richard-

son valve is made to strike the lip not at the corner where the stricture is but in the curved portion of the lip between the valve-seat and
266 the corner, where it expends its force in a sort of pocket or annular trough within and underneath said extended lip. In the Waterman valve, the pressure within the chamber due to the expansive force is always greater than in the Richardson, everything else being equal; and besides, the jet of steam escaping between the valve and valve-seat in the Waterman valve and striking into the corner made by the horizontal and perpendicular walls of the chamber below is deflected, and shoots up by the corner of the valve so as to still further assist in wearing off the delicate corners of the stricture which are necessary in the operation of either the Waterman or the Richardson valve.

In speaking of the experiments with the Waterman valve, I have only mentioned the pressure indicated at the first opening of the valve, I believe. I find by my minutes that these pressures decreased as the boiler was relieved by the valve falling back to forty pounds upon the casing of the valve, and twenty-two pounds upon the extended portion of the valve when the valve closed, the valve closing at eighty pounds when it opened at eighty-five, so that the reduction of the steam by the valve before closing was proportionally larger in the Waterman valve than in the Richardson valve. And further, it should be noticed that the pressure within the chamber in the Waterman valve, due to the expansive force of the steam, was twenty-two pounds when the valve closed, notwithstanding the pressure within the boiler was eighty pounds; while with the Richardson valve, when the pressure was at one hundred pounds within the boiler, the pressure within the chamber was only five pounds, going to show conclusively that in the Waterman the steam was issuing through the stricture with much greater force than in the Richardson, and at this stage with more than four times the force.

Int. 14. You have described the means furnished by the Richardson and Waterman valves, respectively, for overcoming the increased power of the spring due to its compression. Is there any contrivance in the Naylor valve for overcoming or relieving from the increased pressure of the spring when the valve is lifted; and, if yes, what?

Ans. I have already said in the course of this deposition that the impinging force of the steam upon the lip of the Naylor valve assisted directly in overcoming the pressure of the spring, and I have said the same in regard to the Richardson valve. But I now say this feature is not found in the Waterman valve.

267 Int. 15. What is the office of the bent lever in the Naylor patents?

Ans. The office of the bent lever in the Naylor patent is to form an indirect connection between the valve and the spring by means of a lever or levers, so that as the valve rises the leverage increases for the purpose of enabling the direct action of the steam under the valve to more easily overcome the pressure of the spring, as the tension of the spring is increased by the raising of the valve.

Int. 16. Look at Exhibits Nos. 3, 4, 8, and 9, marked ruch in the case of Ashcroft v. The Boston & Lowell Railroad, and state whether said exhibits, or either of them, are described in either, and which of the patents you have been inquired of about?

Ans. The Exhibits 3 and 4 are entirely different from anything described in either of the patents which have been inquired of in the course of this my examination. Exhibit 8 is different from any description in any patent which has been inquired of in this examination, but it appears to me to be considerably like the Beyer valve, if it is like

any of the valves described in any of the patents. It is not like any other valve described in any of the patents, and it is unlike the Beyer valve in its mode of operation, as well as I can see, because in the Beyer valve the space between the lip attached to the valve and the lip attached to the valve-seat is less at the outer extremity than at the inner extremity towards the valve-seat. I don't think this Exhibit 8 is so, but I cannot tell certainly by looking at it. Exhibit 9 appears to me to be very much like Exhibit 8, but differing somewhat in the shape of the two lips as compared with the two lips in Exhibit 8.

JUNE 13, 1873.

Int. 17. In the experiments you made, did you discover any difference between the Waterman and the Richardson valves in the time occupied in relieving the boiler?

Ans. I did. It took about twice as long to relieve the boiler so as the valves would close with the Waterman, as in the Richardson valves.

Cross-examination, de bene esse, by JAMES B. ROBB, esq., of counsel for defendant.

Cross-int. 18. In answering direct interrogatory 5, what did you understand Exhibit C to be?

268 Ans. On referring to the 5th direct interrogatory and then going back to the 4th, it appears that Exhibit C was the English specification of William Naylor, A. D. 1863, No. 1830 of that year. I have no other recollection about it than what appears from the deposition.

Cross-int. 19. Which specification in the document marked "Exhibit C," do you refer to; the specification filed January 21, 1864, or that filed July 21, 1863?

Ans. I don't now know of any difference between the two. What I did refer to in my evidence more particularly was so much of that specification of Naylor as refers to the drawings shown at Figs. 1 and 2, and 5 and 6, attached to that English patent and making part of the same.

Cross-int. 20. Is not the edge of the valve as described in the patent on which this suit is founded, outside the valve seating, cupped or turned downward?

Ans. It is turned downward. I shouldn't say it was cupped.

Cross-int. 21. What distinction do you make between cupped and turned downward?

Ans. I don't make any distinction for the purpose of this case or for the purpose of mode of operation of the Naylor valve. It isn't of any consequence whether it is a cup or not. The valve is turned downward, and if it were turned the other side up it would then constitute a cup. There is no difficulty in seeing what it is.

Cross-int. 22. Point out the exhibit in which it can be seen.

Ans. It can be seen in Exhibit K, C. W. T., Examiner, at Fig. 1 of the drawings.

Cross-int. 23. Then, in your judgment, there is no difference or substantial difference between the valve shown in Exhibit K, and that referred to in the 20th cross-interrogatory, is there? Is that what you mean to say?

Ans. I don't see any essential difference.

Cross-int. 24. Is not the valve described in the said Richardson's patent so constructed that the steam, as it escapes from the boiler, strikes against the overhanging lip, and is thereby directed downward against

the bottom of a chamber, and reacts or recoils, producing an upward pressure against the lip of the valve?

Ans. No; it is not. The Richardson patent says: "With my improved safety-valve, constructed as now described, and attached
269 to the generator in the usual way, the steam, escaping in the direction indicated by the arrows in Fig. 1, first lifts the valve from its seat at the ground joint E E, and then passing into the annular chamber D D acts against the increased surface of the valve-head, and by this means, together with its reaction, produced by being thrown downward upon the valve-seat E E, it overcomes the rapidly-increasing resistance of the spring or balance, lifts the valve still higher, and escapes freely into the open air until the pressure in the generator is reduced to the degree desired, when the valve will be immediately closed by the tension of the spring or balance."

Now, the language which I have just quoted from the patent is perhaps very similar to the language of the interrogatory with regard to the action of the steam in the chamber of the Richardson valve; but in the Richardson valve the action of the steam against the extended lip is due largely to the impinging force of the jet, which strikes into an annular trough, as I have before stated, so that its projectile force is substantially killed out, so to speak, and the steam brought to a state of rest by plunging into the trough and into the steam already in that trough, similar to the manner in which the force of a jet of water is killed out when it plunges into water in a state of rest in a cask or other vessel. The direction of the jet towards the lip is such that it is not deflected by the lip merely, but slightly it is deflected by the lip and upon both sides of the point where it strikes, and *of three* were nothing in the way, it would reach the bottom of the chamber by going downward upon each side of the trough; but it cannot go one way because of the jet of steam which is constantly passing out at the ground joint, and therefore, as a matter of fact, it will to some degree be deflected upon the bottom plate of the chamber, and to some degree it will cause what the patent calls a reaction so as to lift slightly upon the lip; but the lifting upon the lip of the escaping steam in the Richardson contrivance, other than what is due to the force of the jet striking the lip, is mainly due to the expansive force of the steam after it has impinged against the lip, acting upon both sides of the chamber, one side and the upper side being against the lip, the other side and the lower side being against the face of the valve-seat, and this expansive action takes place in consequence of the stricture at the outer wall of the chamber and between it and the overhanging valve-lip.

270 Now, this can be illustrated by reference to the Beyer valve. There is a lip upon that valve, but it is so formed and arranged in relation to the ground joint that it does not receive and destroy the impinging force of the jet of steam, but it does little more than deflect that jet, the main force of the jet still continuing outward after it leaves the lip, as has been abundantly proved by the experiments to which I have testified with regard to that valve where the steam issued through the ground joint at a speed due to a pressure of ninety pounds to the square inch, and yet produced an actual pressure upon the lip of only about eight pounds; while in the Waterman valve, where the steam issued through the ground joint with a speed due to a pressure of only eighty-five pounds to a square inch, the effectual pressure of the jet was eighty-five pounds minus the amount of expansive pressure which was at the same time represented upon the upper lip of the Waterman valve, which was fifty-five pounds, as well as I recollect, leaving a force due

to the jet of thirty pounds to the inch, although the pressure in the boiler was greater with the Beyer than with the Waterman. And again, with the Richardson valve, and with the steam at one hundred pounds, the force of the jet of steam when the boiler was at a pressure of one hundred pounds was twenty pounds, which was about double what was indicated in the Beyer proportionally.

Comparing now the Richardson valve with the Naylor valve, it will be seen that the pressure upon the lip, due to the force of the jet, is full twice as much as it is in the Naylor. And, besides, the pressure upon the plate below in the Richardson valve when the boiler indicates a pressure of one hundred pounds, and when the jet strikes with a force of twenty pounds, was also twenty pounds, while in the Naylor valve, when the force in the boiler was at ninety pounds, as well as I recollect, the pressure of the jet below the extended lip, due to whatever force might be generated in the Naylor valve by striking upon the seat below, was one and one half-pounds less than nothing, showing that there was no reaction there for the purposes of lifting the valve, nor was there any expansive force there for the purpose of lifting the valve; and the reason why there is neither one or the other there, is because that there is no chamber there such as in Richardson's valve; nor is there any stricture there, but the jet of steam is simply deflected downward into that passage-way for the purpose of being carried out of doors.

271 (Answer objected to as not responsive.)

Cross-int. 25. Is not the valve described in said Richardson's patent so constructed that the steam as it escapes from the boiler strikes against the overhanging lip?

Ans. Yes; I have already so stated several times in the course of my direct examination, and have just so stated in answer to the last interrogatory before this.

Cross-int. 26. Is it not thrown downward upon the valve-seat E E, or bottom of the chamber?

Ans. Yes, it is, as I have stated somewhat at large in answer to the 24th cross-interrogatory.

Cross-int. 27. Is there not a reaction in it produced by being thrown downward upon the valve-seat?

Ans. Yes, there is; as I have incidentally stated in answer to the 24th cross-interrogatory, and I will explain a little further as to that reaction by being thrown downwards.

If there was no bottom to the chamber in the immediate neighborhood of the point where the jet of steam strikes the lip of the valve, then there would be no such reaction. This is clear from the results of the experiments to which I have testified here with the Naylor valve. That valve is not now here before me, but the drawing from which it was made is here, attached to the reissued patent Exhibit K. Now, there is a recess below the valve-lip in the Naylor valve, as represented and described in this patent, and so there is in the model made in accordance with this patent; and there is a bottom to that recess three inches away from the valve-lip. And notwithstanding the steam is pitched down that recess with a force and velocity equal to full half what is due to the pressure of ninety pounds within the boiler, there is no reaction, so as to produce any pressure upon a gauge connected with that chamber, as the experiment proves. So that, unless the bottom is in the immediate neighborhood of the jet of steam, so as to be struck in the immediate neighborhood of the lip by said jet, there will be no reaction for any practical purpose, and then it will be very little for any practical purpose, unless there is a stricture to prevent the free escape of

the steam, and then there will be a reaction, and the reaction will be mainly by the expansive force of the steam.

272 (All of the above answer after the first paragraph objected to as irresponsive.)

The effect of the reaction in the chamber of the Richardson valve which would take place without the stricture can be pretty well illustrated by this valve, Exhibit A, which contains something more than is described in the Richardson patent. It will be observed that attached to this valve, and outside the extended lip, there is another curved lip, similar to the curved lip upon the valve, but curved in a converse direction. This is for the purpose of giving the escaping steam a cast upwards, so as not to make it uncomfortable for the engineer, who usually is stationed in the immediate neighborhood of the valve on a locomotive. I have seen some experiments made with this Richardson valve, having this outer and upwardly curved lip so attached that it could be moved upward and downward in its position and everything else remain equal about the valve, and I found that the mere moving upward or downward of this outward lip would affect the opening and closing of the valve, showing that there was a reaction of the steam in consequence of this outer lip within the chamber of the Richardson valve and under the extended lip upon the valve. And if this outer lip upon this valve, Exhibit A, were removed, it would be necessary to the best working of the valve that the stricture of the chamber beneath should be slightly reduced in its dimensions.

Cross-int. 28. Look at the drawings of the Richardson patent and state how much that "stricture," as shown there, should be reduced in the case mentioned in the last sentence of your preceding answer.

Ans. Not any. It is small enough now, I think.

Cross-int. 29. Did you not understand that in the preceding interrogatories where reference was made to the Richardson valve you were interrogated about that valve as it was described in the patent?

Ans. Yes.

Cross-int. 30. And you were speaking of that valve as it was described in the patent, were you not?

Ans. Yes, unless when I spoke of it as having something added to it more than was described in the patent, as is the case with the model Exhibit A, and then it contains the same Richardson valve as is described in the patent.

Cross-int. 31. Does not the reaction mentioned in the 27th cross-interrogatory produce an upward pressure against the lip of the valve?

273 Ans. Yes, it does, as I have stated and explained in answer to the 27th cross-interrogatory.

Cross-int. 32. In your answer to cross-interrogatory 27, you state that there is a recess below the valve-lip in the Naylor valve, as represented and described in his patent. Is that recess suitable to produce a recoiling action of the steam upwards against the under surface of the valve, which shall have the effect to assist in opening the valve?

Ans. No, it is not; and I have said it was not, and proved that it was not by experiments as explained, by way of illustration, in answer, I think, to the 27th cross-interrogatory. What I mean by the recess is that referred to in the second claim of the patent, where the patentee says he claims "The safety-valve C, with its overhanging, downward curved lip, or periphery and annular recess D, substantially as herein shown and described, and for the purpose set forth."

And again in the third claim he says: "The annular recess D, surrounding the valve-seat, substantially as herein set forth."

Cross-int. 33. Which part of the valve as shown in the drawing of the reissued patent do you understand to be referred to by the words "recess D," just quoted by you?

Ans. All that annular recess which surrounds the main passage-way of the valve, including its bottom, which turns the steam outward through the horizontal discharging orifice at B.

Cross-int. 34. Would not that be more properly called a chamber if constructed as you understand it to be?

Ans. No, unless the passage-way of a house from the chambers to the lower floor is called a chamber. It is usually called a hall or entry.

Cross-int. 35. Is it properly called a recess constructed as you understand it to be?

Ans. No, it is not. I have no objection to the word recess in that place. It doesn't make any difference what you call it, the operation being the same.

Cross-int. 36. What change would you make in it, constructed as you understand it to be, in order to make that part a suitable recess to cause the steam to act upwards against the under surface of the valve?

Ans. I would take it out of the contrivance altogether; then I would put the chamber of Richardson right under the lip, shaping the corner of the lip as Richardson has, and fitting the valve-seat up to it as
274 Richardson has, as described in his patent. That is the only way that I know of to reconstruct the Naylor valve so as to make it work at all acceptably for any practical purpose when a common spring is used upon it.

(Witness, while answering, directed the examiner to strike out the words "out close to the lip," and substitute the words "up to it" after the words "valve seat.")

Cross-int. 37. Why did you strike out the words from the preceding answer "out close to the lip"?

Ans. Because I didn't like it. They failed to express clearly what I intended to say.

Cross-int. 38. Would it make any difference in the principle of the operation of the valve in the case mentioned in the 36th cross-interrogatory if the bottom of the chamber should be carried out beyond the outer edge of the lip and terminated by a vertical wall outside of the lip?

Ans. I don't think I understand the question. It might make a very great difference. If you will describe the contrivance as a whole that you mean to inquire about I will endeavor to answer your question. The Richardson patent says:——

(Counsel for defendant asks the witness whether he cannot answer the preceding interrogatory without reading from the Richardson patent. The question is: Would it, in your judgment, make any difference in the principle of the operation of the valves constructed as stated in answer to cross-interrogatory 36, whether the bottom of the chamber of Richardson was "fitted up to the lip," or carried beyond the lip?)

(Witness says:)

I do not now well understand of what the counsel wishes to inquire; but as well as I do understand, what he means to inquire is, if the Richardson valve were constructed so that the structure were upon the outer periphery of the lip, instead of upon the inner, as described in Richardson's patent, whether it could make any difference in the operation of the valve, everything else being equal, and my answer is, no; it would still be the Richardson valve, but I think it would be necessary

to vary somewhat the dimensions of the stricture, when it was constructed that way.

Cross-int. 39. What difference would you make in the dimensions of the "stricture"?

275 Ans. I think I could make it slightly larger, by which I mean slightly wider between the lip and the edge of the valve-seat.

Cross-int. 40. About how wide?

Ans. I don't know; wide enough to work well by experiment.

Cross-int. 41. Suppose the diagonal lines shown in the drawings of the reissued Naylor patent, just below the letters D D, to indicate a diaphragm with perforations, would not the space inclosed within the diaphragm and vertical walls and the overhanging lip be a suitable recess for producing an upward pressure against the under surface of the overhanging lip of the valve?

Ans. No.

Cross-int. 42. Why not?

Ans. Because it wouldn't be a close chamber, such as is described in Richardson's patent. I don't think any valve, operating as this Richardson valve does, would operate well without a close chamber, or substantially a close one. And there is no doubt but the apertures here are large ones, because by the patent the steam is to escape through those apertures mainly as it is blown off at the valve.

(All after the first sentence objected to as irresponsive.)

Cross-int. 43. Do you mean to testify that a valve constructed as suggested in the 41st cross-interrogatory would not in operation produce an upward pressure against the under surface of the overhanging lip of the valve by the steam after it passed the ground joint?

Ans. No; but the question now is varied from what it was before. I understand the question now to be simply this: Could not the steam passages which are represented in the drawings of the Naylor valve, at the point where the outer tube is connected with the inner one, be made so small as to cause the escaping steam to press upward against the under side of the lip? My understanding of the question before was in the practical view of this case, and whether if it should be made out that the drawings represented a diaphragm at the point inquired about, with openings through it so that a portion of the steam should escape there, whether then the Naylor valve would not be a good practical valve.

Cross-int. 44. Hear the question read again, if you please, and answer it.

(Cross-int. 41 read to witness.)

276 Ans. I do hear it read again, and I answer as I did before, and I find the word "suitable" in it, and the word "suitable" was not in the last question.

Cross-int. 45. Do you mean to declare upon your oath that the chamber or recess, or whatever else it may be called, constructed as supposed in the 41st and 43d interrogatories, would not be suitable to cause an upward pressure upon the under side of the overhanging lip?

Ans. Certainly I do not. What I mean to say is, that in my judgment such a contrivance would not produce such an upward pressure upon the under side of the lip as to be suitable to the successful operation of the valve.

Cross-int. 46. Why not?

Ans. Because, with a valve so modified, it wouldn't be good for anything, in my judgment.

Cross-int. 47. Is that an answer to the question, in your judgment?

Ans. I think it is.

Cross-int. 48. What do you mean by a close chamber like Richardson's in your answer to one of the preceding interrogatories?

Ans. I mean just what I said.

Cross-int. 49. What was that?

Ans. I said "because it wouldn't be a close chamber such as is described in Richardson's patent."

Cross-int. 50. Do you understand the chamber described in Richardson's patent to be a close chamber in any proper sense? and, if so, point out that part of the specification which describes a close chamber.

Ans. Yes, I do. The chamber has no orifices for the steam to pass out otherwhere than at the stricture, and that is what I mean by a close chamber such as is described in Richardson's patent. Now the hypothetical chamber inquired of is not such a close chamber as that. And in order to make myself further understood, and by way of explanation, I will state further, that if instead of the orifices the whole passage-way was closed up at the points inquired of, then that chamber would be a close chamber, but it would not be such a close chamber as is described in Richardson's patent.

Cross-int. 51. Why would it not be such a chamber as is described in Richardson's patent?

277 Ans. Because that in the Richardson patent one of the boundaries of the close chamber is the lip of the valve, and that lip has a configuration which bears a peculiar relation to the ground joint of the valve through which the steam escapes into it, which peculiar relation would not be found in the Naylor patent if the chamber were a close one. Moreover, the chamber in the Richardson patent has an outlet which is peculiarly formed so as to present a stricture, which stricture is variable as the valve rises, and therefore, if in this Naylor contrivance there was a close bottom to the chamber at the point inquired of, and there was the peculiar configuration of the lip in relation to the valve-seat which is in Richardson's as above stated, then this Naylor valve so modified would be good for nothing, because it would not have the peculiar stricture of Richardson.

Cross-int. 52. Suppose a valve so constructed, that is, "if instead of the orifices the whole passage-way was closed up at the points inquired of," as stated by you in answer to the 50th interrogatory, would rise suddenly when the pressure of the steam reached the point at which it was set to rise, say seventy pounds, or within one pound in excess of that, and close within three or four pounds below the point at which it was set to rise, and keep the pressure at or below the point at which it rose, would it, in your judgment, be considered a worthless valve?

Ans. It might do all that and still be worthless; because the conditions of firing might be such as to make the hypothetical valve inquired of do just what the question supposes, and still the thing have no value because it wouldn't meet the requirements of a steam boiler safety-valve in practical use.

Cross-int. 53. Then, although you knew that a safety-valve were so constructed and operating, you would not consider it a useful valve for the reasons given in the preceding answer; is that so?

Ans. That is so. What I mean to say is, that if a valve were constructed like the hypothetical valve inquired of, and somebody had been able to swear that it had produced exactly the results implied in the foregoing question, without stating what the conditions of firing were, and other manipulations in regard to the boiler, I should still be of the opinion that such a valve was good for nothing for any practical purpose

over and above the common safety-valve, and not quite as good as that.

And I know another thing, that if a valve were constructed
278 like the hypothetical one inquired of, and were put upon a locomotive such as is used for running any considerable passenger or freight train, and with the fire working at its full capacity for making steam in a locomotive, the working of the engine in connection with the boiler was stopped and the fire kept running to its full capacity, the boiler would either be blown up or the valve would be ruined. I don't state this upon theory alone. I have seen it tried.

Adjourned.

JUNE, 14, 1873.

Cross-int. 54. On what locomotive was the experiment tried, and when and where?

Ans. I don't know what locomotive it was. The locomotive was at the shops of the Boston & Lowell Railroad, and it was there that I saw it tried. It can't tell exactly when; it was some months ago.

Cross-int. 55. Who was present besides yourself?

Ans. M'r Richardson, the complainant in this case, and M'r William C. Hibbard, who testified as an expert in the suit of Ashcroft *v.* The Boston and Lowell Railroad.

Cross-int. 56. Was it not prior to April 25, 1871, that the experiment was tried?

Ans. I don't remember. It was some time ago.

Cross-int. 57. Was it not before M'r Hibbard testified in the case of Ashcroft *v.* The Boston and Lowell Railroad Company, in the spring of 1871?

Ans. Whether it was before he first testified in the case I don't know, but I think he has given some testimony in the case upon that very experiment.

Cross-int. 58. In the "hypothetical" valve before mentioned, would not the steam after leaving the ground joint impinge upon the overhanging lip?

Ans. Yes, after a manner, the same as I have described in speaking of the Naylor valve proper.

Cross-int. 59. Would it not be turned down and strike against the bottom of the recess?

Ans. It would be turned down and strike against the bottom of a recess, but not such a recess as is described in the Naylor patent; it would be such a recess as I have described in the hypothetical valve.

279 Cross-int. 60. Did you not understand that I was interrogating you in reference to that hypothetical valve?

Ans. I understood that you were, or ought to be; but I didn't care to be misunderstood, and so I made the explanation after answering the question categorically.

Cross-int. 61. Would the steam after leaving the ground joint in the "hypothetical" valve be turned down and strike against the bottom of the recess of that "hypothetical" valve?

Ans. Yes.

Cross int. 62. Would not the steam, in that case, on striking against the bottom of that recess—I mean in the "hypothetical" valve, so called—act upwards against the under surface of the valve as it issued forth into the atmosphere?

Ans. Yes, it would, after a manner; but I don't mean to be understood as saying that it would ever touch the surface of the lip after striking the bottom so as to lift upwards. It would act expansively in the close chamber of this hypothetical valve, as I understand it.

Cross-int. 63. Is it necessary, in your judgment, that the particles of steam which do or may strike against the bottom of the chamber, or recess, should also strike against the under surface of the overhanging lip in order to produce a recoil action upon that under surface?

Ans. No, I think not. That depends very much upon what you mean by recoil, and particularly what you mean by recoil action. If a small shot of solid metal were projected through the ground joint of the hypothetical valve it would be deflected by the lip and would impinge upon the bottom of the recess or chamber, and if this ball were of steel, or other elastic material, it would recoil after impinging upon the face of the bottom of the chamber, or perhaps, more properly speaking, rebound and go up against the under surface of the curved lip, striking against it. But with the steam I don't think that would take place, because if the steam did recoil or rebound from the bottom and take an upward movement, it could never get to the under surface of the curved lip for reason of the jet of steam that is constantly being deflected upon the surface of the curved lip covering the whole of it, but would impinge against that jet and thereby produce an upward lift upon the valve by crowding the jet of steam still harder against the lip.

280 Cross-int. 64. It would impart its force or energy to the intervening particles of steam, would it not, to some extent, in the direction in which it was moving when it met the jet?

Ans. I don't care to indorse all that; I think it would do just what I have said.

Cross-int. 65. Can you say, from your own knowledge on the subject of the laws governing the action of moving bodies, that the statement which you decline to indorse is not true?

Ans. I don't like to. I have no hesitation in saying I don't believe it is true, and I do say so.

Cross-int. 66. You have no hesitation in saying, have you, that the steam in the chamber of the Richardson valve acts to contribute to the lifting of the valve by what you call its expansive force?

Ans. Not in the least.

Cross-int. 67. Now, what do you mean by "expansive force"? Is it not true that the steam is passing through that chamber during the operation of the valve with a velocity equal at least to fifteen hundred feet in a second of time?

Ans. What I mean by expansive force is that force which acts inside of a steam boiler and is indicated by the index of a steam-gauge connected with the chamber of the boiler. It is true that the steam is passing through that chamber, but with what velocity I don't know.

Cross-int. 68. I don't ask you to state the velocity of the steam, but to say whether its velocity is not at least fifteen hundred feet a second.

Ans. I don't know whether it is or not; but I don't believe it is.

Cross-int. 69. Why don't you believe it?

Ans. Because I believe it is less.

Cross-int. 70. Have you any knowledge upon the subject?

Ans. That depends upon what you mean by knowledge upon the subject. I don't know how fast it travels through the chamber of the Richardson valve, especially when the amount of pressure in the steam-boiler is not stated as a part of the proposition.

Cross-int. 71. Isn't the Richardson valve used mainly upon locomotive-boilers?

Ans. That depends upon what you mean by mainly. There are more used there than anywhere else.

281 Cross-int. 72. What proportion of them, which you have personal knowledge of in use, are on locomotive-boilers?

Ans. I have no personal knowledge about it any further than this. I have seen more of them on locomotive-boilers than anywhere else, and they are more particularly useful upon locomotive-boilers than anywhere else, as compared with other safety-valves. I have one myself, with an inch aperture, which I put on my boiler in place of a common safety-valve, something over two inches in diameter, and I find it much more efficient than the old two-inch valve was. M'r Richardson put one on my boiler of half-inch diameter, and that I found was more efficient than the old one of two inches diameter, which I took off. I also found it more efficient in relieving the boiler than the Naylor valve of which I have testified in course of this deposition, which I had in the same place on the same boiler.

(Last part of answer, all after the first sentence, objected to as irresponsive and volunteered.)

Cross-int. 73. Do you know the usual pressure of steam at which locomotives are run or operated?

Ans. No; I do not.

Cross-int. 74. Have you any idea what it is?

Ans. I have an idea that it is 100 pounds and upwards to the square inch.

Cross-int. 75. Now answer the second branch of the 67th cross-interrogatory, if you please.

Ans. I don't know whether it is or not, but I don't believe it is.

Cross-int. 76. What do you "believe" its velocity to be when the valve is in operation, judging from your knowledge or observation of the operation of the valve under different circumstances?

Ans. I haven't got any definite idea about it. I never made any observation with a view to find that out.

Cross-int. 77. Have you any idea upon that subject derived from reading?

Ans. No; I have not. I understand that the velocity with which steam will travel under given pressures, and through direct passages, is a matter well understood and tabulated, and may at any time be hunted out from such tables; but inasmuch as these matters are set down in tables, and can there be found when wanted, I do not think
282 it best to load my memory with them, to the exclusion of other matter of more importance; and besides, there are no tables that I know of that can tell how fast the steam will travel through the chamber of Richardson's valve, and I don't believe anybody has ever found out how fast it travels through the chamber of Richardson's valve. What the average rate of motion is through the chamber of Richardson's valve can be approximately ascertained, undoubtedly, when all the conditions are known. The first condition required would be the amount of pressure in the boiler. The next condition the area of the discharging orifice at the valve-seat. The next the area of the chamber itself through which the steam moved in its passage out. Then, I think, there might be an approximate answer to the question, because I think it could be ascertained approximately from the tables what the speed through the valve-seat would be, and then I think it would be fair to say that if a section of the area in the chamber were one hundred times as much as the area of a section at the valve-seat, then the average velocity in the chamber would be one one-hundredth part of the velocity at the valve-seat.

(All of answer after the words, "it no; I have not," objected to as irresponsive and volunteered.)

Cross-int. 78. Does M'r Richardson anywhere in his specification in terms say that the lifting of the valve to overcome the rapidly increasing resistance of the spring or balance is produced by what you have termed in this examination "expansive force"?

Ans. I don't think he does. I don't remember to have seen it there. I will look and see. But I find the following in the patent which does not quite, certainly it comes pretty near stating in terms what the question inquires of: "The nature of my invention consists in increasing the area of the common safety-valve outside of its ground joint, and terminating it in such a way as to form an increased resisting surface against which the steam escaping from the generator shall act with additional force after it has lifted the valve from its seat at the ground joint, and so by overcoming the rapidly increasing resistance of the spring or scales, ensure the lifting of the valve still higher, thus affording so certain and free a passage for the steam to escape as effectually to prevent the bursting of the boiler or generator, even when the steam is shut off and the damper left open."

283 Cross-int. 79. Do you understand him to mean by that quotation that the steam acts in the manner there indicated by its "expansive force"?

Ans. I should so understand it, and especially because he states that he terminates this extended surface "in such a way," etc. If the steam was not to act expansively, I cannot see what the termination of the extended surface would have to do with it. But when it is understood that this termination is at the stricture, and that the very purpose of the stricture is to make the steam act expansively, it will be easily seen that he makes that stricture a part of that description.

Cross-int. 80. Does it make any difference as to the action of the steam in the chamber whether it be direct by its velocity, or "expansive," as you term it, whether that chamber be of the same form or size as shown in the drawings of the Richardson patent, or otherwise, provided the outlet for the steam be of the proper size to form what you call the stricture?

Ans. Yes; it does. I don't mean to be understood that any slight deviation from the form and size described by Richardson would make any substantial difference; but the form and size of that chamber is important.

Cross-int. 81. What variations in form and size could be made, in your opinion, and still retain the requisites to produce the desired effect by expansive force?

Ans. I don't like to state just what variations could be made and still have the valve work as it ought to, because I haven't experimented with that express view; but I have experimented somewhat in regard to such a valve as the question inquires of where the passage for the steam was direct, there being no chamber, but only the stricture at the termination of the passage similar to the stricture in the Richardson valve. I will describe as well as I can the valve with which I made the experiments, and then state as well as I can the results of those experiments.

(The witness is not interrogated by the preceding interrogatory as to any experiments with any other than what he understands to be the Richardson valve, and counsel for the defendant objects to his making any statements of such experiments.)

Cross-int. 82. What do you understand the patentee means by that part of the specification in which he says that the "transverse sec-

284 tion shown in the figure" (referring to the annular chamber D D) "may be of any desirable form or size"?

Ans. I understand that he means what he says, and means to be understood as not confining himself to the exact form and size so long as the mode of operation of the valve is maintained substantially according to his description; meaning to be understood that, notwithstanding mere formal changes, the valve would still be his so long as substantially the same mode of operation was contained in it. For instance, suppose the extended portion was made a little wider or narrower, as might be desired, the valve would be his. So much relating to the size. And then, as to form, suppose that the extended portion, which is described in the patent as a curved lip so arranged in relation to the pitch of the ground joint as to receive the impinging force of the steam nearly at the radial line of the curve, the lip were formed with an angle coming up to that radial line upon each side of it upon the lip, at an angle, say, of 45°, with the radial line, a little more or less, or any other form which would take the jet of steam in a suitable manner.

Cross-int. 83. Then you understand him to say, by the words "any desirable form or size," that he doesn't confine himself to the exact form and size so long as the conditions mentioned in your answer are observed, do you?

Ans. Well, I rather prefer to put down my own answers, and I don't care to change what I have said above, which seems to me can be easily understood.

Cross-int. 84. Answer the question if you can without evasion, or decline to answer it.

Ans. I have no further answer to make.

Cross-int. 85. Would it make any substantial difference as to the expansive action of the steam in that chamber if it were twice as large as shown in the drawing of the patent? Would it not be then suitable to produce the desired effect?

Ans. I don't think it would make much difference. I think it would be suitable to produce the desired effect if it were twice as large, and everything else was as it should be.

Cross-int. 86. What do you mean by the words "and everything else was as it should be"?

285 Ans. I mean everything else as is described in Richardson's patent; and, besides, I mean that in my judgment, everything else being equal, it would be best to have the stricture a little larger.

Cross-int. 87. For a valve of the size shown in the drawing?

Ans. Yes; with a chamber twice as deep.

Cross-int. 88. Does it make any difference whether the "stricture," or opening for the escape of the steam into the air, in your judgment, be inside or outside of the "lip"?

Ans. I have already answered this question in the course of this cross-examination, and I refer to my answer to that question for an answer to this.

Cross-int. 89. Does it make any difference whether the "stricture," or opening for the escape of the steam into the air, be on the inside or outside of the lip of the valve, when the chamber is altered in size, as stated in the preceding interrogatories and answers?

Ans. It makes no difference which is due to the alteration of size in the chamber, by which I mean mere alteration in depth of the chamber.

Cross-int. 90. What changes of the form of the under side of the lip

could be made, in your judgment, without affecting the principle of the operation of the Richardson valve?

Ans. I have already mentioned one, which was to make the lip angular instead of curved; I don't now think of any other; I dare say there may be various other forms that would do.

Cross-int. 91. What substantial difference would there be, if any, between the chamber or annular recess in Fig. 1 of the drawings of the Naylor patent if the bottom of the recess were solid at that part shown by the diagonal lines below the letters D D, and a chamber of the Richardson valve modified or changed as stated in the preceding interrogatories and answers; that is, with a chamber twice as deep as shown in the drawing of the Richardson patent, and the opening for the escape of the steam into the air on the outside instead of the inside of the lip? Would there be any other difference than at or about the opening around the lip of the valve for the escape of the steam?

Ans. I have already answered a similar question with regard to this hypothetical valve now inquired of, the only difference being that the Richardson chamber is now made twice as deep as it was before; and I have already said if it was made twice as deep, it would still be
286 a Richardson valve; so I have answered the question before, but I will answer it again as well as I can. There would be another difference, as I have before stated, I believe; and that is in the formation of the under side of the lip, which makes the upper part of the boundary of the chamber. But I then said, and I say now, that if the lip in the hypothetical contrivance inquired of were shaped like Richardson's, that then the valves would be good for nothing. But I believe I did not then say why it would be good for nothing; nor did I say that it was unlike Richardson's, except so far as that it was good for nothing; and I will now state, in accordance with the question, wherein it would then differ from Richardson's, although the lip were modified to conform to Richardson's.

In the Richardson valve, when the steam commences to escape through its ground seat, it is immediately caught up in the chamber by means of the stricture at the outer portion of the lip, where it acts within the chamber to raise the valve by its expansive force acting against the lip of the valve, while at the same time the impinging force acts upon the lip, the effect of which is to raise the valve so high that the overhanging portion of the lip is carried up to the level of the bottom of the chamber; or, to state it in another way, it is carried up to that point from which a further raising of the valve produces a corresponding enlargement of the stricture, and that is a necessity to the successful working of that valve. There is no such provision existing in the hypothetical valve inquired of, and it is for that reason that the valve is good for nothing. And it would be good for nothing as I mean to be understood although the lip had the peculiar configuration of the lip in the Richardson valve at its under side.

Cross-int. 92. Does Exhibit M, now shown you, represent the Richardson valve correctly?

Ans. I don't know what you mean by "represent the Richardson valve correctly," but it is a picture which correctly represents the general construction of the Richardson valve.

Cross-int. 93. Do you mean to declare upon your oath that you do not know what I mean by that question?

Ans. I do. I mean to declare upon my oath just what I have above stated.

287 Cross-int. 94. What is there in that question that you do not understand the meaning of?

Ans. I do not know whether you mean to inquire whether the picture represents correctly the suitable dimensions for constructing the Richardson valve.

Cross-int. 95. Is there any part of that "picture" that does not represent correctly the Richardson valve?

Ans. No; not as to its general character, that I can see.

Cross-int. 96. What do you mean by its general character?

Ans. I mean the contrivance described in the patent of Richardson. This picture represents the outer curved lip for giving the jet of steam, as it escapes from the stricture, a cast upward, which is not described in the Richardson patent; otherwise, it is a fair representation, I believe, of that contrivance of Richardson.

Cross-int. 97. Does that picture, apart from the outer curved lip, as correctly represent or show the Richardson valve as it is shown by the drawings annexed to the patent?

Ans. Yes; I think so. I think if it were substituted for the drawings to the patent it would be sufficient for all the purposes of the patent if the letters and references were made to correspond.

Cross-int. 98. Suppose a valve, constructed in exact conformity to that picture, rose in blowing off one-twelfth of an inch, would there be any, and what, if any, appreciable variation in the size of the opening around the lip, which you call in this case the stricture?

Ans. The first thing which I have to say in answer to that is this: I don't think it would be practicable to construct a valve exactly in accordance with the dimensions of this picture, because that, by and according to this picture, the lip upon one side is represented as coming down over the valve-seat considerably more than it is upon the other side; but neither side is represented as coming down as much as a twelfth of an inch below the top of the bottom of the chamber, so that if a valve were constructed according to that side which comes down the farthest, then the valve in raising a twelfth of an inch would enlarge the orifice there. And if a valve was constructed according to the other lip, and then the valve were raised a twelfth of an inch, there would be a considerable enlargement of the stricture upon that side.

288 Cross-int. 99. How much lower does the lip come down upon one side than the other?

Ans. I can't tell. I haven't the means of measuring it; but it is obvious to any one having good eyes that the lip on the left-hand side of the picture comes down lower than the lip on the right-hand side of the picture, a fact which never exists in any Richardson valve made as they are usually made, because the parts are all turned in a lathe accurately, and therefore the lip comes down equally upon all sides, and it is necessary to the good working of the valve.

Cross-int. 100. What is the width of the opening at the "stricture," as shown in Exhibit M?

Ans. In the neighborhood of a thirty-second*th* part of an inch, I should say; I have no means of finding it out accurately.

Cross-int. 101. How much does the end of the lip come down below the corner of the valve-seat?

Ans. Which lip? Do you mean upon the left-hand side of the picture or upon the right-hand side?

Cross-int. 102. Suppose the lip in a valve to be constructed like that shown on Exhibit M, except that the lip came down below the valve-seat one-twelfth of an inch, and in operation it rose only one-twelfth of

an inch, that is, at its highest lift the opening was no larger than shown in the drawing; would that valve, in your judgment, be substantially the Richardson valve?

Ans. To answer this question as it now stands would, in my judgment, lead to a misunderstanding of the facts concerning the Richardson contrivance, for the reason which I will state. According to this picture the inner surface of the extended lip where it shuts down to make the stricture is conical, and so is the outer surface of the valve-seat on which the lip shuts. Now, as I understand the question, it is whether that, with a valve constructed according to this picture, with a lip coming down a twelfth of an inch over the valve-seat, and the valve raising a twelfth of an inch when it blows off, the size of the stricture still remaining the same—whether it would then be the Richardson valve. And my objection is this, that if the sides were tapering as I have described, the valve could not be raised at all without enlarging the stricture.

Now, in the drawings attached to the Richardson patent, there is not clearly shown any such tapering sides; but I have here in my
289 hand a certified copy of the model of the Richardson valve from the Patent Office at Washington, and the sides here are tapering, as I have said they were in the picture Exhibit M, so that the valve of Richardson, according to this model, could not be raised at all without enlarging the stricture. But if the valve were constructed as the question proposes and without tapering sides, as I have explained, then it is obvious that if the lip extended downward the twelfth of an inch and the valve were raised only a twelfth of an inch, that there would be no enlargement of the stricture, and if that was as high as the valve was made to rise, then the valve would be good for nothing, the same as the hypothetical valve which has been described here is good for nothing, and would not be the Richardson any more than it is.

Cross-int. 103. Why would the valve be good for nothing in that condition?

Ans. Because it couldn't possibly relieve the boiler.

Cross-int. 104. Why not?

Ans. Because the stricture would be too small to allow the steam to pass out free enough to relieve the boiler.

Cross-int. 105. About how wide should the opening be at the stricture to relieve the boiler when it is blowing off at a lift of a twelfth of an inch?

Ans. I can't tell; it would depend upon circumstances. But I do know that it should be wider than what is necessary and proper to have the opening when the valve first begins to blow. And that is one of the peculiarities of the Richardson contrivance. The stricture is small enough so that any considerable portion of the steam escaping through the valve-seat as it first lifts, is caught by the stricture so as to make the steam act expansively in the chamber against the lip to assist the pressure in the valve proper to overcome the pressure of the spring, and it is necessary that afterwards that stricture should become enlarged so as to admit the passage outward of an increased volume of steam, because as the valve lifts there is an increased volume of steam to be discharged through the stricture, and the boiler cannot be relieved without that increased discharge through the stricture. If it were not for this fact, it would be better to have the lip close up to the valve-seat merely for the purpose of lifting the valve. But that would do no good, because the boiler cannot be released without discharging steam into the atmos-

290 phere or somewhere else, and so it must get through somewhere in order to relieve the boiler.

Now, I think I can illustrate this somewhat by reference to experiments which I saw made with the hypothetical valve as to which I have been inquired of and testified in this examination. In that experiment, when the steam first commenced blowing by the raising of the valves, there was no considerable expansive force exercised in the chamber, but the whole thing acted like a common safety valve, opened, the steam was wire drawn through it, but the boiler was not relieved to any considerable extent. The fire in the locomotive was kept up; the steam escaping from the valve increased in volume and so did the pressure of the steam in the boiler, but the expansive force in the chamber increased, and the valve went on rising. By and by the escape of steam through the valve proper was so great that it couldn't pass out at the stricture of the hypothetical valve with any pressure which the spring of the valve could support, and then the valve took a hoist and carried the lip clear above the surrounding casing, enlarging the stricture so as to relieve the boiler.

Now, so far the opening was well enough, if it was only for the purpose of opening that valve; but, then, a valve that will only open isn't a good one; it is necessary that it should shut up again, and shut up under the pressure of the same spring that it opened against, and this is the antagonism which enters into the requirements which this contrivance of Richardson is made to answer and meet. Now this hypothetical valve, when it was once got open, wouldn't shut up again until the pressure within the boiler became so reduced, by blowing off otherwheres, as to reduce the volume which escaped through the valve by the reduction of the pressure in the boiler, and then the spring crowded it slowly back to its place, as this pressure on the boiler was reduced by blowing off; but all that steam was wasted, and the spring of the valve was so upset that it wasn't good for anything, as well as I remember, and the whole thing was perfectly useless.

If the stricture in the hypothetical valve had been sufficiently close to take the first escaping steam and hold it so as to get the expansive force beneath the lip, and thereby assist the direct pressure within the boiler in raising the valve, and the stricture had thereby become enlarged to a considerable extent, then the boiler could be relieved, notwith-

291 standing the pressure on the spring had increased. And after the pressure within the boiler had been reduced some three to five pounds, according to the completeness of the contrivance, then the compressed spring could master the force of the steam within the chamber, and force it, the valve, back towards its seat, thereby diminishing the volume of escaping steam, and at the same time reducing the expansive force within the chamber, and at the same time the force due to the jet which impinges against the lip until the escaping jet of steam becomes so small, as the experiments prove, that only five pounds additional pressure are upon the lip, and there being two and a half or five pounds, as the case may be, less pressure upon the valve proper, the spring is able to master the whole pressure, and immediately close the valve.

Now this is a difficult thing to accomplish. All the points must be correct and delicately applied. No bungling contrivance can do it, athough it may come somewhere in the neighborhood of it, and do something like it in some respects. It is easy enough to make a valve that will relieve a boiler if you don't want to shut it up again afterwards, and it easy enough to make a valve that will shut up after

it opens, if you don't want it to relieve the boiler. A common safety-valve will do that. But it is not easy to make a valve that will open and relieve the boiler and then shut up again at the same pressure at which it opens. Nobody has done that and probably nobody ever will. Richardson has come very near to it, nearer than anybody has before him, because he has made a valve that will open and relieve a boiler so that you can't blow it up, and will close by reducing the pressure 2½ pounds to a square inch, where the pressure within the boiler is 100 pounds to a square inch, while the hypothetical valve inquired of, in the experiment which I saw, did not close until the pressure within the boiler was so reduced as to prove that the contrivance as it was there tried was perfectly worthless, and for the reasons which I have endeavored to set out further back.

Cross-int. 106. It was obvious then, was it not, during that experiment, that the chamber was not a suitable recess?

Ans. Yes, it was. It wasn't obvious to me then that the upper wall of that chamber wasn't suitable, but it was obvious to me that the termination of the lip and its relation to the upper part of the chamber at its outer periphery was entirely unsuitable.

292 Cross-int. 107. Suppose the relation between the termination of the lip and the upper part of the chamber at its outer periphery had been made suitable for the purpose of discharging the steam, would not the operation of the valve then be, substantially this, namely: the steam as it escaped from the boiler acting against the overhanging lip would be directed downwards, striking against the bottom of that recess or chamber, producing a recoiling action upwards against the under surface of the valve as it issued forth into the atmosphere and thus assist to some extent in opening the valve.

Ans. Yes; I believe so. I have already explained how in this hypothetical valve the steam which is deflected downward by the lip might and probably did rebound, so as to assist in raising the valve. Now the question supposes, in addition to what was before stated in regard to this hypothetical valve, an increased opening at the outer periphery of the valve, and I do not now see how that change could essentially change the action of the recoiling steam, or rebounding steam, from the bottom of the chamber upward.

Cross-int. 108. Suppose a valve to be constructed like Exhibit M, with the side of the opening or stricture so formed that the space would be of the same width when the valve was on its seat as it would be when raised one twelfth of an inch, or at its highest lift, would it in that case, in your judgment, be the Richardson valve?

Ans. I have already answered that question. I said that it would not, and that it wouldn't be good for anything, and that I believe is true whatever the size of that opening might be.

(Adjourned.)

JUNE 20, 1873.

Cross-int. 109. Do you know what became of the "hypothetical valve" with which you saw the experiments tried, referred to by you in the latter part of the last paragraph of your answer to cross-interrogatory 105?

Ans. As well as I recollect, the hypothetical valve there spoken of was the one which I saw tried at the Lowell Company's shop in Cambridge, about which I have before said I thought M'r Hibbard had given some testimony in regard to these valves; and as to what became

293 of that valve, I do not know of my own knowledge, but I think it now stands in the next room, in company with some other models there.

Cross-int. 110. Will you be kind enough to point it out, describe it by the mark upon it?

Ans. This is the valve which I understand to be the same one I saw used, and is marked, "Ashcroft v. Boston and Lowell Railroad, Defendant's Exhibit G, C. W. T., examiner." But the model, as it stands now, represents with considerable accuracy the Naylor valve, such as is described in the English patent to Naylor, and represented at the Figs. 1 and 2, and 5 and 6; and the same as is described in the American patent to Naylor, and represented at Figs. 1 and 2. This model, Exhibit G, is considerably larger than is represented in the drawings of the patent, it being about the same size in the main delivering orifice as the Richardson valve, Exhibit A, which is two and a quarter inches. But it should be understood that, when that experiment was tried, of which I have testified, it was a contrivance entirely different from that described in the patent to Naylor. The passage-way for the steam outward, after it impinges against the lip, in the Naylor contrivance, was stopped tight immediately at the top of the four radial connections which connect the outer tube with the inner tube of the Naylor contrivance; thus taking out of the valve the passage-way for the steam, as provided by Naylor, and making the upper part of the *the* passage-way a close chamber by stopping the passages, as I have before said; so that all the escaping steam passed outward into the open air between the outer periphery of the lip and the inner periphery of the outer tube or cylinder of the valve, as will be readily understood upon inspection of the contrivance itself.

Cross-int. 111. Suppose the opening around the lip was of sufficient size to allow the free escape of the steam when the valve was lifted one-twelfth of an inch, what in your judgment would have been its operation compared with its operation under the circumstances mentioned by you?

Ans. Then the valve would have worked very much as the Naylor valve works when constructed in accordance with the American patent, as represented at Figs. 1 and 2; but with the steam in the boiler at the pressure it was in the experiment to which I have referred, and with the opening outside of the lip of the size indicated in the question, the valve would never rise one-twelfth of an inch, and probably not much
294 more than half of it, because that the hypothetical contrivance would then have no stricture for any practical purpose.

Cross-int. 112. Why would not that opening in that case be a stricture for any practical purpose?

Ans. Because it is so large it would not act as a stricture. In fact, the terms of the question imply that it couldn't act as a stricture, for by the terms of the question it must be large enough to allow the steam to pass out freely when the valve is a twelfth of an inch high; and, as I have before stated, if the passage-way were so large, then the valve would never lift a twelfth of an inch high, and of course it could not act as a stricture till it did lift the twelfth of an inch high; and, besides it is clear that it wouldn't be a stricture if the valve did lift the twelfth of an inch high, so long as the escaping steam passed freely through it.

Cross-int. 113. Would it not be as much of a stricture when the valve was lifted the twelfth of an inch high as the space for the escaping steam around the lip of the Richardson valve would be a stricture when it was lifted one-twelfth of an inch?

Ans. Certainly not; for it is obvious that in the operation of the Rich-

ardson valve the steam never escapes freely into the open air immediately it passes the ground joint, but the steam is always restricted in the use of that valve after making that passage. The point of difference is this: In the Richardson contrivance the escaping steam is always restricted, but the restriction is variable; in the hypothetical valve, with the free opening for the passage of the steam, the steam would never be restricted at all.

Cross-int. 114. I intended to assume in the question that the valve, in the case put, lifted one-twelfth of an inch from its seat. Now, while in that condition, does not that opening operate as much to restrict the escaping steam as the opening at the so-called stricture around the Richardson valve operates to restrict the escaping steam in that valve?

Ans. No. By the conditions of the question, the opening in the hypothetical valve is large enough to admit of the free passage of the steam into the atmosphere immediately it passes the ground joint. Such a state of things never exists in the Richardson valve in operation. With the valve a twelfth of an inch high, the steam is still restricted at the outer periphery of the extended area, as the experiments which I have testified of, in the course of this direct examination, clearly prove.

295 Cross-int. 115. Do I understand you correctly if I understand you to say that, in the cases supposed, if the Naylor valve be raised one-twelfth of an inch, with an opening around the lip of sufficient size to admit of the free escape of the steam into the atmosphere, and the Richardson valve be lifted one-twelfth of an inch high, with an opening around the lip sufficient to admit of the free escape of the steam into the atmosphere, the opening in the latter case would operate as a stricture, while in the former case it would not? I mean taking the Naylor valve in the condition it was in as described by you when the experiment was tried, except that the opening around the lip was modified as assumed.

Ans. No; I haven't said any such thing of the Naylor valve, as I understand it. What I did say was of a very different thing from the Naylor valve, although I said it operated somewhat like it. And here I wish to remark again that I prefer to make my own answers, and if I haven't made the answer to the preceding question so as to be understood I will endeavor to answer it further.

Cross-int. 116. Now please hear the preceding interrogatory read again, and give your attention to the reading of it, that you may understand its meaning, and answer it, if you please.

(Cross-interrogatory 115 read to witness.)

Ans. On hearing the question read again I find it contains another assumption than the one I referred to in my last answer, and that is, that in the use of the Richardson valve the steam does escape freely into the open air immediately it passes the ground joint. I have already said that it does not, and that the experiments prove it.

Cross-int. 117. In what part of the question do you find the "other assumption"?

Ans. Nearly in the middle of the question I find these words, "and the Richardson valve be lifted one twelfth of an inch high with an opening around the lip sufficient to admit of the free escape of the steam into the atmosphere."

Cross-int. 118. Do you mean to say that in the Richardson valve, while blowing off under the condition stated in the question, the opening operates as a stricture, while in the Naylor valve, in the hypothetical condition named in the question, the opening around the lip while blowing off does not operate as a stricture?

296 Ans. No. What I mean to say is that the Naylor valve proper is not inquired of in the question, as I understand it, but the valve which I understand was inquired of, and is now inquired of, is a hypothetical valve having a close chamber and having the Beyer lip outside of the valve proper, and with an opening outside of that lip so large that when the valve is raised a twelfth of an inch the steam will escape freely into the open air through the chamber.

Cross-int. 119. I understood you to say that one of the experiments about which you have testified was with Exhibit G, having the space between the radial arms closed or covered so that all of the steam was discharged through the opening around the lip. Now, suppose that opening around the lip to be made of the same size as the opening around the lip of the Richardson valve when that valve is raised one-twelfth of an inch in blowing off; and suppose Exhibit G, in the altered condition named and having the opening of the size mentioned, be raised one-twelfth of an inch in blowing off, would the opening in the Richardson valve be any more a stricture than the opening of Exhibit G?

Ans. Counsel understood me correctly with regard to the experiment. Then the question goes on and says, "Now suppose that opening around the lip to be made of the same size as the opening around the lip of the Richardson valve when that valve is raised one-twelfth of an inch in blowing off;" and in answer to this, I say, no; because it appears to be obvious that, if the two valves inquired of be of equal dimensions, an equal quantity of steam will be discharged in each through the ground joint with equal pressure inside the boilers, and if the aperture which admits the steam from the chamber into the atmosphere be the same in each valve, then there will be the same stricture in one as in the other upon that escaping steam. And yet it is possible there may be some difference in the two cases due to the difference of deflection of the jet of steam issuing through the ground joint in the two valves.

Cross-int. 120. Would it make any difference, in your judgment, in the operation of the opening for the escape of the steam in the case mentioned in the preceding interrogatory, if a portion of the steam escaped into the air through openings in the bottom of the annular space of Exhibit G as modified, the opening around the lip being contracted proportionally, or, in other words, if the steam passing into the air should be discharged both ways?

297 Ans. No; I don't think it would make any practical difference in the hypothetical valve inquired of.

Cross-int. 121. Would it make any difference in the operation of Exhibit G; in the condition mentioned or referred to in the preceding interrogatory, if the spaces between the radial bars were increased, and the opening below were contracted so as to leave the outlet for the steam at that point of equal area to the openings through the bottom of the annular space mentioned in the preceding interrogatory?

Ans. No; I don't think it would make much practical difference. I think the valve would be just as worthless in one case as in the other. But I think that, as a matter of fact, the stricture upon the steam would be greater if the diaphragm instead of being at the top of the radial bars were in the outlet at the place indicated by B, in the Naylor reissued patent, the area of the passages through the same being the same in both cases.

Cross-int. 122. Do you think the valve would be "worthless" in that case because, in your judgment, it would not lift high enough to discharge steam from the ground joint fast enough to relieve the boiler?

Ans. Yes. I will endeavor to explain my meaning. In order to

raise the valve one-twelfth of an inch under the conditions inquired of, it will be necessary to get the pressure inside of the boiler a good deal higher above the first blowing-off point than will be necessary with the Richardson valve, because that in the hypothetical valve the stricture, whenever it is a stricture, is constant and not variable as it is variable in the Richardson valve. And in the Richardson valve, according to the proposition of the patent, the stricture is about one-sixty-fourth of an inch when the valve begins to open, and therefore the steam is immediately restricted upon the opening of the valve, notwithstanding the quantity issuing from the ground joint is very small, and immediately this restriction causes the steam to act expansively in the chamber under the lip, and assists the pressure within the valve in raising the valve up to one-twelfth of an inch. Now no such effect will be brought to bear materially in the hypothetical valve inquired of to assist the valve in overcoming the pressure of the spring, and raising it up to this height of one-twelfth of an inch. All that will have to be done mainly by the pressure of the steam within the boiler acting upon the valve proper in the hypothetical contrivance inquired of. And therefore consid-
298 erable more pressure will have to be exerted upon the valve proper, in the hypothetical contrivance, after the first opening, in order to get the valve up to the height of one-twelfth of an inch. And consequently the same spring cannot be used in both cases, because that in order to bring the valves up one-twelfth of an inch and sustain them, there with the same pressure within the boiler, and with the same aperture at the stricture, the spring in the hypothetical valve will have to have much shorter range of movement in proportion to its pressure, so as to allow the steam to begin to blow off at less pressure in the hypothetical valve than in the Richardson valve. This difference all resolves itself into this: In the Richardson valve the stricture varies in size as the quantity of steam blown off varies, while there is no such variation in the hypothetical valve inquired. There are some differences in the form of the lips in the two cases which are also important to some extent in this matter, but the difference is mainly due to the variation in size of the stricture in one case, while there is no such variation in the other.

Cross-int. 123. If a machinist, or a person skilled in the business of making safety-valves, were directed to so construct the openings for the escape of the steam in the Naylor valve into the air that the steam in passing through those openings should exert a pressure on the lip of the valve, by causing a portion of the steam to pass upwards around the lip, would he, in your opinion, make the valve like this Exhibit G, as it now appears?

Ans. I don't quite understand the hypothesis assumed and inquired of, because that I do not understand that it is the steam passing through the openings which exerts a pressure on the lip of the valve, by causing a portion of it to pass upwards; but I can understand how, if the passages inquired of are made very small, so as to cause the steam to act expansively in the chamber, that then the expansive force of the steam will assist in raising the valve; and if a person skilled in these matters were told to do that, I think he might readily do it, but I think he would not make it like Exhibit G, as it now appears.

Cross-int. 124. Is that valve constructed so that the steam on issuing between the valve and its seat impinges against the curved projecting portion of the valve, a portion being directed downward, and another portion ascending past the edge of the valve, in such a manner that the annular recess and the projecting lip of the valve are available
299 in causing an increased pressure on the valve, or such an in-

creased pressure on the valve as to overcome the increased resistance of the spring due to its compression?

Ans. No; that valve is so constructed that the steam in issuing between the valve and its seat impinges against the curved projecting portion of the valve; and, when the valve first begins to blow, the whole of the escaping steam passes upwards around the lip of the valve; afterwards, when the valve blows a little more strongly, a portion of the steam will ascend past the edge of the valve, and a portion of it will be directed downwards through the steam passage, and out through the other opening. When the valve blows still stronger, all the steam is directed downwards through the annular recess, and out through the lower opening into the air, taking with it a current of air which is pressed into the chamber by the atmosphere between the lips and the outer cylinder, in consequence of the tendency to a vacuum produced by the jet of steam as it is deflected downwards, and through the annular recess. The projecting lip of the valve is made available in causing an increased pressure on the valve, so as to overcome the increased resistance of the spring due to its compression by means of the impinging jet of steam as it escapes through the ground joint of the valve, the annular recess being of no use in this raising of the valve by the jet of steam, except in so far as it affords a passage-way through which the steam can pass readily as it is deflected from the lip of the valve.

Cross-int. 125. Could you not cause any portion of the escaping steam in Exhibit G to be discharged upwards by using a discharge-pipe attached to the lower opening of suitable dimensions?

Ans. Of course you can, so long as you do not discharge more than can go out between the edge of the lip and the outer cylinder of the passage-way, and through the small pipe upon the lower passage.

Cross-int. 126. Suppose the workman was directed to place Exhibit G upon a boiler, and set it so that one-half of the escaping steam should be discharged through the discharge-pipe, and the other half should be discharged through the opening around the lip; could he not do that readily by means of a discharge-pipe of suitable size?

Ans. Of course he could, just as I have said before; but if this valve had been placed before him at the time of the date of the sealing
300 of the English patent to Naylor, with the instructions supposed in the question and no others, I think his answer would be, "I don't know how to do it."

Adjourned.

JULY 8, 1873.

Cross-int. 127. What must be the relative size of the areas of the openings at the ground joint and around the lip, or at the lip, to constitute the latter a structure in the sense in which you have applied that term in giving your testimony?

Ans. I know of no precise and positive relations of the parts inquired of; but the best sizes, so far as I do know, are those stated by Richardson in his patent, where he says:

"To enable others skilled in the art to make and use my invention, I will proceed to describe its construction and mode of operation. To the head of the common safety-valve, indicated by all that portion of Fig. 2 lying within the second circle from the common centre, I add what is indicated by all that portion lying outside of the said circle, in about the proportion shown in the figure."

Now the diameter of the main discharging orifice at the ground joint, as represented at Fig. 2, is two and a quarter inches, nearly, and the annulus which constitutes the extended area and comes down over the

close chamber has a breadth of about a quarter of an inch, and an extreme diameter of about three and a quarter inches. This gives an area of about 3.97 inches for the main opening of the valve, and about 2.36 inches for the extended area.

But it should be understood that the actual lifting power due to the stricture produces some effect in raising the valve upon the area which constitutes the ground joint, and which lies between the main aperture of the valve and the extended area which constitutes the lip of the value. The stricture described in the patent, in connection with the areas just given, is "one-sixty-fourth of an inch for an ordinary spring balance." This stricture is an annulus, having a diameter of about three and a quarter inches. These are all the sizes which I find stated in the patent with the exception of one other, which is as follows: "For a strong spring or balance this space should be diminished, and for a weak spring or balance it should be increased, to regulate the escape of the steam as required."

301 Now, the area of the opening at the ground joint will always depend entirely upon the height at which the valve is lifted to produce that opening; and, according to the best of my knowledge, one-twelfth of an inch is about as much as a Richardson valve, of the size represented at Fig. 2 of the drawings of the patent, ordinarily lifts when blowing off, at a pressure in the boiler of 100 lbs. to an inch; and with a lift of one-twelfth of an inch the valve represented at Fig. 2, where the diameter of the main opening of the valve is two and a quarter inches, the area of the opening at the ground joint would be about fifty-nine one-hundredths of an inch, while the area of the opening at the stricture, when the valve is constructed as represented at Fig. 3 of the drawings of the patent, would be about sixty-eight one-hundredths of an inch, as near as I can make it out.

It is obvious that the opening at the ground joint and the opening at the stricture will both vary as the valve varies in height, and they will also vary somewhat in their relations to each other as the valve varies in height.

Cross-int. 128. How did you determine the areas given above in the last two paragraphs?

Ans. By taking the circumference of the main passage of the valve where the steam first enters the ground joint and multiplying it by the height to which the valve raises for the discharging aperture of the steam at the ground joint; and for the area of the stricture by taking the circumference of the stricture and multifying the same by the distance which the inner corner of the lip of the valve would be from the outer corner of the valve-seat over which the hanging lip extends, as near as I could estimate it by the height to which the valve ordinarily lifts.

Cross-int. 129. Please give the figures of your calculation.

Ans. The formulas are as follows:

$$7 : 22 :: 2.25 : 7.07+$$
$$7.07 \times \tfrac{1}{12} = .59-$$
$$6 : 22 :: 3.25 :: 10.21+$$
$$10.21+ \times \tfrac{1}{15} = .68+$$

Cross-int. 130. What would be the width of the opening around the lip or at the stricture, so-called, in a valve constructed like Exhibit

302 L, marked on the tag "Ashcroft vs. Boston & Lowell R. R., Defendant's Exhibit L, C. W. T., Examiner," when lifted one-twelfth of an inch by the steam while blowing off?

Ans. I have no means of ascertaining accurately, but, as near as I

can measure with a common rule, it would be about one-tenth of an inch.

Cross-int. 131. What would be the area of that opening?

Ans. About one inch.

Cross-int. 132. Suppose the area of that opening in the case mentioned in cross-interrogatory 130 to be one and a quarter inches, would it, in your judgment, operate as a stricture in the sense in which you apply that term?

Ans. I think it would operate as a stricture to some extent; but I do not think the valve would work well when constructed of the size of Exhibit L, and using steam in the boiler at the pressure of one hundred pounds to the square inch.

Cross-int. 133. Why not?

Ans. Because it would not produce sufficient expansive force in the chamber of the valve.

Cross-int. 134. Explain or state why it would not produce the expansive force sufficient.

Ans. Because it would admit through it too easily the steam which escaped through the ground joint when the valve was raised one-twelfth of an inch high, and the pressure of the steam in the boiler was one hundred pounds to the square inch. But this would not be the principal difficulty with the valve. The principal difficulty would be this, as I understand it: If this valve, when it was raised one-twelfth of an inch, had the outer corner of the valve-seat and the inner corner of the valve-lip so far away from each other as to produce an area of one and a quarter inches, then, when the valve was shut down to its seat, the space between the inner corner of the lip and the outer corner of the valve-seat would be too large to catch the steam when the valve first opens and thereby produce the expansive force upon the lip of the valve to raise it from its seat as soon as it should do. It will be necessary that the pressure should be considerably increased in the boiler after the first opening of the valve, so as to lift the valve considerably from its seat in order that enough of steam might escape through the
303 ground joint to be so restricted between the outer corner of the valve-seat and the inner corner of the lip as to cause the steam by its expansive force to assist properly in overcoming the pressure of the spring.

Cross-int. 135. In your judgment, what would be the difference in pressure in that case?

Ans. In what case?

Cross-int. 137 In the case you were speaking of in your preceding answer.

Ans. I spoke of two cases in my preceding answer, one when the valve was first opened and one when the valve was one-twelfth of an inch high, I believe.

Cross-int. 138. Are you willing to answer the question?

Ans. I am when it is a question.

Cross-int. 139. Suppose the area of the stricture, so called, in the Richardson valve to be twice as large as the area of the opening at the ground joint while the valve is blowing off, would it, in your judgment, then operate as a stricture, as you apply that term?

Ans. I think it would, but not for the purposes of a good valve when the valve was constructed of the size of Exhibit L, and used with such a spring as is usually used with the Richardson valve when the boiler carries a pressure of one hundred pounds to the square inch, and the valve is raised one-twelfth of an inch high.

Cross-int. 240. What proportion in size must that opening bear to the opening at the ground joint to cease to operate as a stricture?

Ans. I am not able to say definitely, but I can say that in my opinion there would be no considerable utility in a valve of the size of Exhibit L, and upon a boiler with the pressure of one hundred pounds to the square inch, and the valve raised one-twelfth of an inch, if the area at the lip were some three or four times the area at the ground joint, and everything else remained the same as in Exhibit L.

Cross-int. 141. You say you cannot say definitely. I don't ask you to state definitely, but with the degree of definiteness that your experience or knowledge of the subject suggests.

Ans. I have stated as definitely as I can well. I have never made any experiments to see how bad this valve might be made and still be worth something.

Adjourned.

304 JULY 9, 1873.

Cross-int. 142. Is it not true that the opening at what has been called the stricture will operate more or less effectually as a stricture, as you understand and apply that term, depending upon the amount or degree of the pressure in the boiler while the valve is blowing off?

Ans. Yes, it is, with a given opening at the ground joint.

Cross-int. 143. Please explain that answer.

Ans. It is obvious that the greater the pressure within the boiler the greater will be the amount of steam discharged through the ground joint, if the opening at the ground joint remain of a given size. It is also obvious that, with a given size stricture in connection with the close chamber, such as in the Richardson valve, the more steam there is to be driven through it the greater will be the expansive force of the steam within the chamber, and therefore the stronger will this expansive force act upon the extended area of the lip of the valve to overcome the tension of the spring.

Cross-int. 144. Is it not true that an opening that would operate as a stricture, as you apply that term, under fifty pounds boiler-pressure, would not operate as effectively as a "stricture" under twenty-four pounds boiler-pressure?

Ans. Yes, if you mean by effectively the power exerted upon the extended area in the Richardson valve to overcome the pressure of the spring, as I suppose you do.

Cross-int. 145. Would you consider that opening in the Richardson valve to be or operate as a "stricture" if it were large enough to allow the steam to increase the pressure in the boiler five pounds above the point at which it was set to open before it commenced to relieve the boiler?

Ans. I don't understand the question.

Cross-int. 146. Where were the experiments tried, which you testified about as having been made with the Exhibit Hibbard Naylor Model on your boiler?

Ans. Made in my shop in Everett.

Cross-int. 147. What are the dimensions of that boiler?

Ans. I am unable so state. I think the boiler is rated as eight-horse.

Cross-int. 148. Give the dimensions, as nearly as you can.

305 Ans. It is a tubular boiler, having a fire-box somewhat similar to a locomotive; and my impression is that the boiler, at its cylindrical part, is about two feet in diameter, and perhapt eight feet long.

Cross-int. 149. What do you understand to be meant by the terms "fitting loosely around it," in the Richardson patent?

Ans. I understand "fitting loosely around it," in the patent of Richardson, to refer to the relation of the overhanging lip to the outer edge of the valve-seat, and, taking the patent with the drawings, I understand that it means that that overhanging lip, at its lower rim or corner, should be concentric to and at a uniform distance from the outer corner or edge of the valve-seat E E, and, according to the patent, that distance should be about one sixty-fourth of an inch for an ordinary spring or balance, when the valve is constructed of the size of the drawings belonging with the patent, and the valve is shut close.

Cross-int. 150. Suppose the opening to be one-sixteenth of an inch between the overhanging lip, at its lower edge, and the outer corner or edge of the valve-seat; would it, in that condition, embody the principle of the Richardson valve, as you understand it?

Ans. Yes; if that was the only difference between the valve described in the patent and the valve inquired of; but such a valve wouldn't work well, in my judgment.

Cross-int. 151. Why wouldn't it work well?

Ans. There would be too much time lost between the first and second opening of the valve, and in the mean time the pressure in the boiler would go on increasing, notwithstanding the steam was blowing off at the ground joint of the valve. I believe it is true that there is always two openings of a valve, the first and second opening, when constructed according to the patent of Richardson. But, when the valve is at its best, I am unable to detect any space of time between the first and second openings, because the second follows the first so quickly as to run them both together, so far as my ear is concerned.

Cross-int. 152. How much, in your judgment, would the pressure increase in that valve, or in the valve in that condition, supposing the pressure in the boiler to be 100 pounds to an inch, and the valve set to open at that point?

Ans. I have never tried any experiments to ascertain that; but, as a matter of judgment, I should think that, with a valve constructed
306 like that described in the patent, in form and dimensions, and with the annular stricture the sixteenth of an inch wide when the valve was shut, the increased pressure after the first opening, and before the second, might be two or three pounds, perhaps. In making this statement I wish it to be understood that the valve described in the patent has not the outer curved rim for giving the steam a cast upward, like the valve Plaintiff's Exhibit A, C. W. T., Examiner. This outer rim, when it is used upon a valve, enables the valve to work with something of a wider stricture, everything else being equal, than what is admissible when the valve-seat is naked, as described in the patent.

Cross-int. 153. Suppose that opening—I mean what you call the "annular stricture"—to be so wide as to allow the pressure in the boiler to increase five pounds between the "first and second openings of the valve," would the valve, in that case, embody the principle of Richardson's invention, as you understand it?

Ans. Yes.

Cross-int. 154. Would that opening operate as a "stricture" in that case, in the sense in which you have used that term in giving your testimony?

Ans. Yes.

Cross-int. 155. Suppose that opening to be still larger, that is, sufficiently large to allow the pressure of the steam to increase eight pounds, would it in that case?

Ans. Well, yes; I guess so. I have already said in the course of this

cross-examination that I have never made any experiments to show how bad this Richardson valve might be constructed and still have it good for something.

Cross-int. 156. The principle of construction and mode of operation, or in other words the principle of the invention, would be contained in the valve whether the opening was one-sixteenth of an inch, or so much greater than that as to allow the pressure to increase eight pounds between "the first and second opening of the valve," would it not?

Ans. Yes; I believe so. I have already said in the course of this examination that there are two important features entering into the Richardson valve:

1st. A peculiar stricture by means of which the steam escaping from the valve proper is made to act by its expansion force upon an
307 additional area outside of the valve proper (but practically integral therewith) to assist in raising the valve; this stricture being so constructed and combined with the valve as to be enlarged when the valve is considerably lifted from its seat.

2d. The peculiar construction and arrangement of the additional area or lip in relation to the valve proper, so that the impinging force of the jet of steam escaping through the valve proper is made of direct utility in lifting the valve.

Now, my understanding of this matter is, that Richardson was the first to embody these two features in a valve working together in the manner he has described in his patent, and inasmuch as the valve inquired of would have both these features working together somewhat in the manner described in his patent, I think it would contain the principle and mode of operation invented by Richardson.

Cross-int. 157. Does the preceding statement of your understanding of this invention agree with or differ from the description of it as made by Richardson himself in his specification?

Ans. It agrees with it, so far as I know. He hasn't stated it in the same language, I believe, but he has described the contrivance there, which comes within my description, as I understand it.

Cross-int. 158. Are not the projecting downward curved lip of the valve and the annular chamber surrounding the valve-seat available in causing an increased pressure on the valve, by which the increased resistance of the spring, due to its compression, is overcome in the Richardson valve, although the opening for the escape of the steam into the air be so large as to admit of an increase of pressure of from five to eight pounds between the first and second openings of the valve?

Ans. Yes.

Cross-int. 159. How many different Richardson valves have you experimented with, and at what places, and when?

Ans. I believe I have never made but one experiment myself with the Richardson valve, or maybe two; but I have seen experiments with three different valves, I believe; and in the experiments which I say I made myself, the manipulations were by another.

The first experiment which I saw made with a Richardson valve was at the works of M'r Ashcroft, who is the defendant in this case. The experiments were made by M'r Ashcroft himself, or by his em-
308 ployees. I think I only saw one valve experimented with there which was made strictly in accordance with the Richardson patent. When those experiments by M'r Ashcroft were made I don't now remember, but it was before I had given my first evidence in this case.

The next experiment which I saw with a Richardson valve was made at Troy, New York, at the establishment of Mess'rs Starbuck, and by

M'r Richardson, the patentee of the patent upon which this suit is brought. I don't remember when that was. It was a good while ago, and before I gave any evidence in this case.

The next experiment which I saw with the Richardson valve was made at the shops of the Lowell Railroad, at East Cambridge, by M'r Richardson himself, and that was a good while ago. I believe that was before I gave any evidence in this case.

The next experiment which I saw was at the same place last mentioned, and by M'r Richardson, and the time was subsequent to the making of my first deposition in this case, I believe.

The next experiment, as well as I remember, was at the same place last mentioned, the experiment being made at my suggestion with a view to showing M'r Hibbard some facts in regard to the Richardson valve as compared with the Waterman valve, in the operation of the two. That was not very long ago. I think some two or three months since. The experiments were made by an employee of the Lowell Railroad, as directed by myself.

I have before stated in the course of this deposition that I had a small Richardson valve upon a boiler belonging to myself, and I have that small valve there now, and have occasionally witnessed its operation.

I will also further state that my first experiments concerning this inquiry were made with a valve having one of the features of Richardson's contrivance, but not the other. It had a stricture, with a sort of chamber between the valve-seat and stricture, but it had not the curved lip, nor had it such a chamber as Richardson's.

HERVEY WATERS.

Attest:

JOHN G. STETSON, *Examiner.*

309 The following is the opinion of the court read by the honorable George F. Shepley, circuit judge, on the eighth day of May, A. D. 1874, upon entering the decree in this cause dismissing the bill of complaint with costs to the respondent, namely:

Opinion of the court.

Circuit court of the United States, district of Massachusetts.

EDWARD H. ASHCROFT
v.
THE BOSTON AND LOWELL RAILROAD COMPANY. } In equity.

SHEPLEY, J.:

The bill in this case charges the defendants with infringement of letters patent of the United States reissued November 9, 1869, to the complainant, as assignee of William Naylor, of the county of Middlesex, England, for an improvement in steam safety-valves.

The answer of the defendants sets up in defense—

First. That the reissued letters patent are not for the same invention described in the original letters patent.

Second. That William Naylor was not the original and first inventor of the improvements specified in said reissued patent, but that the same were known to others and used by them, as stated specifically in the answer, prior to the alleged invention thereof by Naylor.

Third. That the reissued patent does not cover and embrace the valve used by the defendants.

Fourth. That the valve used by defendants is described and contained in letters patent of prior date to complainant's invention, granted by the British Government to Thomas Green, also to Charles Beyers, and by the United States to Henry Waterman, and also to George W. Richardson, and that the invention of George W. Richardson, described in his patent, was made prior to the invention of Naylor set out in the bill.

The invention relates to spring safety-valves for use on locomotive, stationary, and marine engine-boilers. As the spring on common
310 safety-valves was compressed by the lifting of the valve, the force of the spring became stronger by tension, while inversely, from other causes, the tendency of the valve to rise became weaker. The spring safety-valve, therefore, failed to relieve the boiler, for, as the spring was compressed by the lifting of the valve, its power to resist was largely increased, and if steam was rapidly generated the pressure in the boiler continued to increase while steam was escaping at the valve.

Various attempts have been made, as shown by the various patents in evidence, to obviate this defect in the operation of the common spring safety-valve.

William Naylor, in his specification filed in the Great Seal Patent Office of Great Britain on the twenty-first day of January, 1864, described two methods of obviating this difficulty. One of these methods claimed by him as his invention, he says, "consists, when using a spring for resisting the valve from opening, in the employment of a lever of the first order, one end resting by a suitable pin upon the safety-valve, and the other end of the lever resting upon the spring being bent downward to an angle of about forty-five degrees from the fulcrum, so that when the valve is raised by the steam the other end of the lever depressed upon the spring downward, and at the same time is moved inward toward the fulcrum, thus virtually shortening the end of the lever, and thereby counteracting the additional load upon the valve as it is raised from its seat by the greater amount of compression put upon the spring." This method he claimed as his invention in the specifications of his English patent. These specifications also described another method of obviating the difficulty. This consisted of the following contrivance: A lateral branch or escape-passage was provided for a portion of the steam after it passed the valve, the valve was made to project over the edges of the exit-passage for the steam, and the projecting edges of the valve were curved slightly downward, so that the steam, on issuing between the valve and its seat, would impinge against the curved projecting portion of the valve, and a portion of it would be directed downward into the annular chamber which surrounded the central passage for the steam, which chamber communicated with the exit-pipe, while the other portion of the steam ascended past the edges of the valve. "By this means," he states, "I am enabled to avail myself of the recoil action of the steam against the valve, for the purpose of facilitating the further lifting of such valve when once opened; but I wish it to be understood that I lay no claim to such recoil action, nor to the extension of the valve laterally beyond its seat." And in the claims, at the close of his specifications, he made no claim for any such extension of the valve, or any device for effecting any recoil action of the steam. In fact, Charles Beyer, in his English patent, dated October twenty-first, 1863, before the date of Naylor's patent, had fully described "a valve made to project over the edges of the exit-passage for the steam, and the projecting edges of the valve were curved slightly downward so that the steam, on issuing between the valve and its seat, would

impinge against the curved projecting portion of the valve. The description is as follows:

"This invention consists in forming a flange round the valve, commencing at the outer edge of the valve-facing, which flange is undercut and concave in shape, and the concave side is toward the seating of the valve, which has also a flange upon it, commencing at the outer edge of the valve-seating, but the upper surface of the flange is convex, and corresponds nearly to the concave surface of the flange upon the valve. There is a slight space between the concave and convex surfaces of the two flanges which diminishes toward the outer edge of the flanges. When the steam begins to escape from between the surfaces of the valve it gets between the concave and convex surfaces of the two flanges, and its force thus acts upon a larger area, and reacts upon the concave surface of the valve and causes it to open to a greater extent than the ordinary safety-valve."

It will be seen from this description that Beyer's safety-valve had "an overhanging downward-curved lip or periphery and an annular recess" into which the steam will be directed downward on issuing between the valve and its seat, while a portion of the steam will also impinge against the curved projecting portion of the valve.

Without adverting to the patents of Henry Waterman and other devices older than Naylor's, we have seen that Naylor could not, with propriety, claim to have been the inventor of the combination, in a spring safety-valve, of every form of projecting overhanging downward-curved lip or periphery with an annular recess surrounding the valve-seat into which a portion of the steam is directed as it issues between the valve and its seat.

Neither of the attempts to overcome the objections to the spring safety-valve in common use appears to have been so far successful as to have introduced either of the inventions into common or general use.

Letters patent of the United States issued September twenty-fifth, 1866, to George W. Richardson, of Troy, N. Y., for an improvement in safety-valves. The purpose of a safety-valve being to open and relieve the boiler, and then to close again at a pressure as near as possible to that at which the valve opened, Richardson accomplished it so far as to invent a valve which would open at the given pressure to which the valve was adjusted and relieve the boiler, and then close again when the pressure was reduced about two and one-half pounds to the inch when the pressure in the generator was one hundred pounds to the inch. This practically answered to the required conditions for a useful spring safety-valve. It went very soon into general use. The complainant, who is a manufacturer, in this country, of safety-valves, then, as appears from the evidence in the record, endeavored to find something to anticipate the invention of Richardson. Finding in the Patent Office a model of the Naylor valve, with an overhanging lip and an annular chamber surrounding the valve-seat, he goes to England and purchases the right to the Naylor invention, and although Naylor himself had disclaimed the recoil action of the steam consequent on the passage of a portion of the steam downward into the annular chamber surrounding the central chamber, while the other portion of the steam ascends past the edges of the valve, and had also disclaimed the extension of the valve laterally beyond its seat, the complainant caused the patent to be reissued to him, as assignee of Naylor, with the following claims which were not in the original patent:

"2. The safety-valve C, with its overhanging downward-curved lip or

periphery and annular recess D, substantially as herein shown and described, and for the purpose set forth.

"3. The annular recess D surrounding the valve-seat, substantially as herein set forth.

"4. The combination of the valve C and the annular recess D, as herein set forth, and for the purpose described."

From the history of the art as previously given, and from a 311,312 comparison of the original with the reissued Naylor patent, as well as from the language of the claims in the reissued patent, it is manifest that if these claims can be sustained, it can only be for the combination of the described valve with its overhanging downward-curved lip, with precisely such an annular recess surrounding the central chamber as he describes. Naylor did not invent the overhanging downward-curved lip or periphery, nor was he the first to use an annular chamber surrounding the valve-seat into which a portion of the steam is deflected as it issues between the valve and its seat. His claim must therefore be limited to the combination of the other elements, with precisely such an annular recess as he has described, and operating in the described manner so far as such recess, separately or in combination, differed in construction and operation (if it did materially differ in those respects) from those which had preceded it. The claims cannot be made to cover a safety-valve like the Richardson valve, which, in its construction and mode of operation, is substantially different from the valve described in the Naylor patent, simply because the Richardson valve, in common with the Naylor valve, has the overhanging downward-curved lip or periphery, and an annular recess surrounding the valve-seat, into which a portion of the steam issuing from between the valve and its seat is deflected. The differences between the Richardson and Naylor valves in construction are apparent upon an inspection of the drawings in the respective patents. The difference in the mode of operation is most clearly proved by the testimony of the experts in the case. In the Naylor valve it appears that it was the intention of the inventor to use the impact of the issuing steam upon the concave lip of the valve to assist in lifting it, and only this, except so far as it was aided by the diminution of atmospheric pressure on the top of the valve, consequent upon the issuing of a portion of the steam in an upward direction around the periphery of the valve, the annular chamber into which the steam is discharged on leaving the valve serving no other purpose than that of a conduit for the steam, when the valve is constructed in accordance with the drawings in the original patents. In the Richardson valve, when the valve opens, the steam expands and flows into the annular space around the ground joint. Its free escape is prevented by a stricture or narrow space formed by the outer edge of the lip and the valve-seat. Thus the steam escaping from the valve is made to act by its expansive force upon an additional area outside of the valve proper, to assist in raising the valve, this stricture being enlarged as the valve is considerably lifted from its seat, and varying in size as the quantity varies of the issuing steam. There would be no such variable stricture in the Naylor valve, and, in fact, there would be no stricture in it without substituting a diaphragm for some equivalent device for the radial bars which, in the drawings in the original patent, connected the inner and outer cylinders, and if Naylor's annular chamber had been intended to be closed, or partially closed, at the bottom by substituting a diaphragm for the radial bars shown in the drawing, or by substituting a small outlet, not shown, for the large one shown in the drawing, for the exit of the steam from the annular

cylindrical chamber, then his device of a bent lever would not only have been useless but injurious in its operation, and this last device is the only one which he claimed in his original patent. The Richardson valve is the one used by the defendant; there is added an extension-cup and upward-curved flange to give an upward direction to the issuing steam and keep it away from the cab of the engine. This is an old device, and does not affect the principles or mode of operation of the valve proper.

There is a substantial difference between the Richardson valve and the valve in the specifications and drawings of the Naylor patent, not merely in degree, but its increased practical utility results from a substantial difference in construction and mode of operation.

Bill dismissed.

313 UNITED STATES OF AMERICA,
Massachusetts District, ss:

I, John G. Stetson, clerk of the circuit court of the United States for the district of Massachusetts, within the first circuit, certify that the foregoing is a true copy of the record and of all proceedings, including the opinion of the court, in the cause in equity entitled Edward H. Ashcroft, complainant, v. the Boston and Lowell Railroad Company, defendant, in said circuit court determined.

In testimony whereof I herunto set my hand and affix the seal
314 of said circuit court, at Boston, in said district, this ninth day of October, in the year of our Lord one thousand eight hundred and seventy-five, and of the Independence of the United States the one hundredth.

[SEAL.] JOHN G. STETSON, *Clerk.*

315 *Bond to party on appeal.*

Know all men by these presents that we, Edward H. Ashcroft, of Lynn, in the district of Massachusetts, as principal, and Andrew L. Haskell, of Chelsea, and William A. Haskell, of Boston, both in the State and district of Massachusetts, as sureties, are held and firmly bound unto the Boston and Lowell Railroad Company, a corporation established by the laws of the commonwealth of Massachusetts, having its principal office in Boston, in said district, in the full and just sum of one thousand dollars, to be paid to the said Boston and Lowell Railroad Company, its certain attorney, successors, or assigns; to which payment well and truly to be made we bind ourselves, our heirs, executors, and administrators, jointly and severally, by these presents, sealed with our seals and dated the second day of April, in the year of our Lord one thousand eight hundred and seventy-five.

Whereas lately, at a circuit court of the United States holden at Boston, within and for the district of Massachusetts, in a suit in equity depending in said court between said Edward H. Ashcroft, complainant, and said Boston and Lowell Railroad Company, defendant, decree was rendered against the said Edward H. Ashcroft, and the said Edward H. Ashcroft having obtained an appeal to remove the said cause to the Supreme Court of the United States to reverse the decree in the aforesaid suit, and a citation directed to the said Boston and Lowell Railroad Company, citing and admonishing it to be and appear at a Supreme Court the United States, to be holden at Washington on the second Monday of October next:

Now, the condition of the above obligation is such, that if the said Ed-

ward H. Ashcroft shall prosecute his said appeal to effect, and answer all damages and costs if he fail to make his plea good, then the above obligation to be null and void; otherwise to remain in full force and virtue.

EDWARD H. ASHCROFT. [L. S.]
A. L. HASKELL. [L. S.]
W. A. HASKELL. [L. S.]

Signed, sealed, and delivered in presence of—
MARTIN LUSCOMB.
GEORGE L. BERG.

Approved.

BENJ. DEAN,
Att'y for Defendants.

A true copy of the bond taken by the judge at the time of allowing the appeal named in said bond, which bond is on file in the office of the clerk of the circuit court of the United States for the first circuit and district of Massachusetts.

Attest:

JOHN G. STETSON,
Clerk U. S. C. C. Mass. Dist.

(Indorsement on cover:) No. 266. Edward H. Ashcroft, appellant, vs. The Boston and Lowell Railroad Company. Massachusetts C. C. U. S. Filed 21st October, 1875.

REC. 266—13

cylindrical chamber, then his device of a bent lever would not only have been useless but injurious in its operation, and this last device is the only one which he claimed in his original patent. The Richardson valve is the one used by the defendant; there is added an extension-cup and upward-curved flange to give an upward direction to the issuing steam and keep it away from the cab of the engine. This is an old device, and does not affect the principles or mode of operation of the valve proper.

There is a substantial difference between the Richardson valve and the valve in the specifications and drawings of the Naylor patent, not merely in degree, but its increased practical utility results from a substantial difference in construction and mode of operation.

Bill dismissed.

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Massachusetts District, ss:

I, John G. Stetson, clerk of the circuit court of the United States for the district of Massachusetts, within the first circuit, certify that the foregoing is a true copy of the record and of all proceedings, including the opinion of the court, in the cause in equity entitled Edward H. Ashcroft, complainant, v. the Boston and Lowell Railroad Company, defendant, in said circuit court determined.

In testimony whereof I herunto set my hand and affix the seal
314 of said circuit court, at Boston, in said district, this ninth day of October, in the year of our Lord one thousand eight hundred and seventy-five, and of the Independence of the United States the one hundredth.

[SEAL.] JOHN G. STETSON, *Clerk.*

315 *Bond to party on appeal.*

Know all men by these presents that we, Edward H. Ashcroft, of Lynn, in the district of Massachusetts, as principal, and Andrew L. Haskell, of Chelsea, and William A. Haskell, of Boston, both in the State and district of Massachusetts, as sureties, are held and firmly bound unto the Boston and Lowell Railroad Company, a corporation established by the laws of the commonwealth of Massachusetts, having its principal office in Boston, in said district, in the full and just sum of one thousand dollars, to be paid to the said Boston and Lowell Railroad Company, its certain attorney, successors, or assigns; to which payment well and truly to be made we bind ourselves, our heirs, executors, and administrators, jointly and severally, by these presents, sealed with our seals and dated the second day of April, in the year of our Lord one thousand eight hundred and seventy-five.

Whereas lately, at a circuit court of the United States holden at Boston, within and for the district of Massachusetts, in a suit in equity depending in said court between said Edward H. Ashcroft, complainant, and said Boston and Lowell Railroad Company, defendant, decree was rendered against the said Edward H. Ashcroft, and the said Edward H. Ashcroft having obtained an appeal to remove the said cause to the Supreme Court of the United States to reverse the decree in the aforesaid suit, and a citation directed to the said Boston and Lowell Railroad Company, citing and admonishing it to be and appear at a Supreme Court the United States, to be holden at Washington on the second Monday of October next:

Now, the condition of the above obligation is such, that if the said Ed-

ward H. Ashcroft shall prosecute his said appeal to effect, and answer all damages and costs if he fail to make his plea good, then the above obligation to be null and void; otherwise to remain in full force and virtue.

EDWARD H. ASHCROFT. [L. S.]
A. L. HASKELL. [L. S.]
W. A. HASKELL. [L. S.]

Signed, sealed, and delivered in presence of—
MARTIN LUSCOMB.
GEORGE L. BERG.

Approved.

BENJ. DEAN,
Att'y for Defendants.

A true copy of the bond taken by the judge at the time of allowing the appeal named in said bond, which bond is on file in the office of the clerk of the circuit court of the United States for the first circuit and district of Massachusetts.

Attest:

JOHN G. STETSON,
Clerk U. S. C. C. Mass. Dist.

(Indorsement on cover:) No. 266. Edward H. Ashcroft, appellant, vs. The Boston and Lowell Railroad Company. Massachusetts C. C. U. S. Filed 21st October, 1875.

REC. 266—13

SUPREME COURT OF THE UNITED STATES.

October Term, 1877—No. 266.

EDWARD H. ASHCROFT, APPELLANT,

vs.

THE BOSTON AND LOWELL RAILROAD COMPANY.

BRIEF FOR APPELLANT, BY FRANCIS FORBES.

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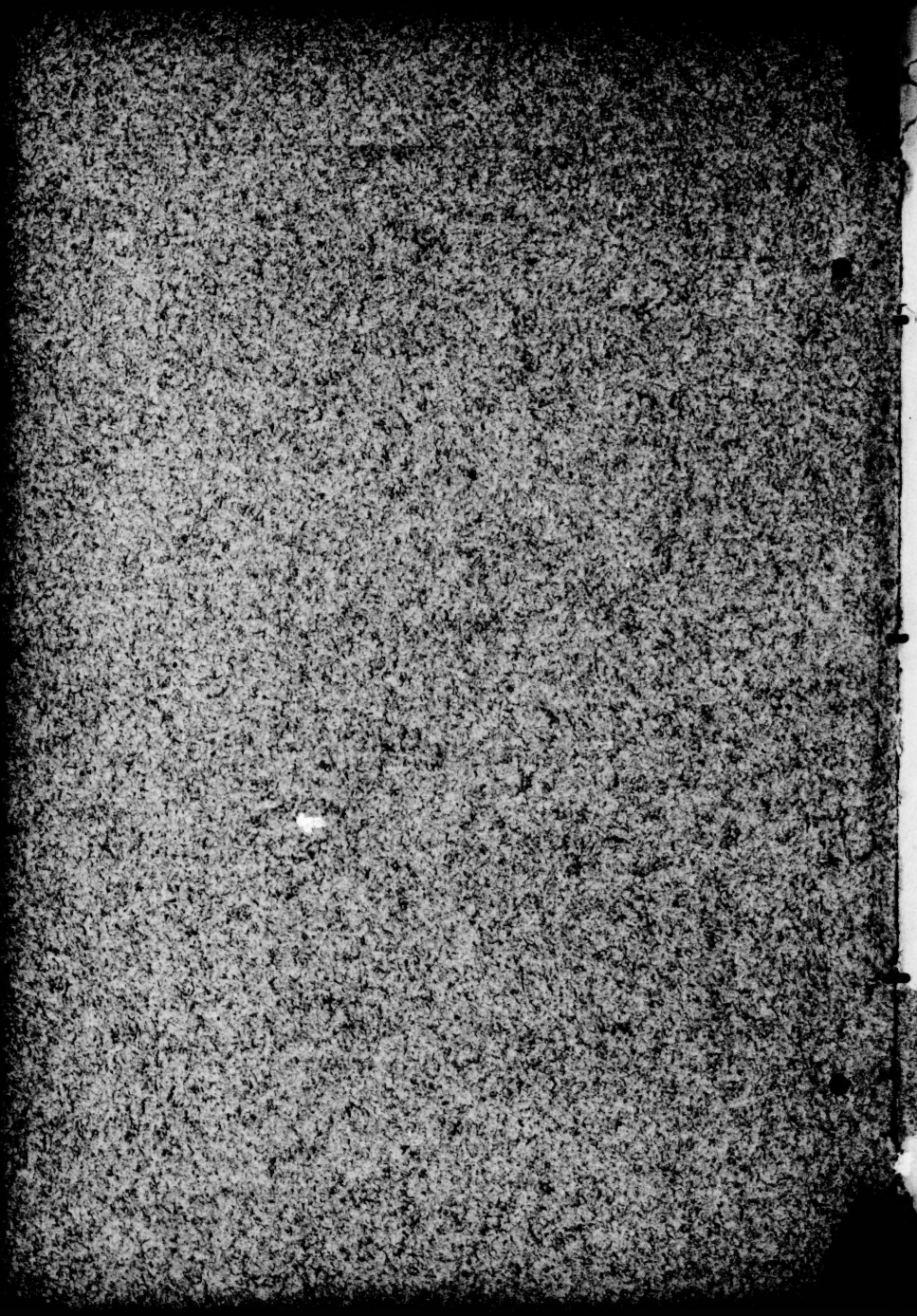

UNITED STATES SUPREME COURT.

EDWARD H. ASHCROFT,
Appellant,

vs.

THE BOSTON AND LOWELL RAILROAD COMPANY.

No. 266.

Brief of Francis Forbes for Appellant.

This is an appeal from a decree of the Circuit Court of the First Circuit, for the District of Massachusetts, in a suit in equity.

The suit was founded on letters patent of the United States, originally granted to William Naylor, October 16th, 1860, for an improvement in steam safety valves, surrendered, cancelled and reissued to the complainant as assignee, November 9th, 1869, for seventeen years, from January 21st, 1864, the date of British letters patent, granted to said Naylor for the same invention; bill was filed December 14th, 1869. It prayed for an injunction, an account of profits and for damages.

The answer was filed February 7th, 1870, and replication of same date.

The answer of the defendant sets up in defense (using the words of Judge Shepley in his opinion).

"*First.*—That the reissued letters patent are not for "the same invention described in the original letters "patent.

"*Second.*—That William Naylor was not the original "and first inventor of the improvements specified in "said reissued patent, but that the same were known "to others, and used by them, as stated specifically in "the answer, prior to the alleged invention thereof by "Naylor.

"*Third.*—That the reissued patent does not cover "and embrace the valve used by the defendants.

"*Fourth.*—That the valve used by the defendants is "described and contained in letters patent of prior "date to complainants' invention, granted by the "British Government to Thomas Green, also to "Charles Beyer, and by the United States to Henry "Waterman, and also to George W. Richardson, and "that the invention of George W. Richardson, de-"scribed in his patent, was made prior to the invention "of Naylor set out in the bill."

Testimony was taken in the usual manner, and the cause was brought to a hearing on the pleadings and proofs before the Hon. Judge Shepley, and a decree entered dismissing the bill, on May 8th, 1874.

The opinion read by Judge Shepley is found at page 188 of Record.

The complainant appealed to this court, assigning error in the decree the dismissal of the bill of complaint.

The Invention.

The invention relates to spring safety valves, and is applicable to locomotive, stationary and marine boilers.

The common weighted lever safety valve was invented in 1681 by Denis Papin.

Prof. Thurston, Pop. Science Monthly for November, 1877.

In drawings of steam boilers made at the beginning of this century, safety valves are shown held down by weights, either above the valve or suspended within the boiler, or placed at the end of a lever, as in the

present mode. When steam was introduced on railroads and ships, weights were abandoned, because they were liable to be lifted by the movement of the boiler, and the valve opened at a lower pressure than desired. Springs replaced the weights, but these were objectionable because the pressure maintained on the valve varied with its rise and the compression of the spring. Waterman, to remedy these defects, took out his patent for a weighted lever valve, so arranged that the lever would not be raised by the jolting of the moving boiler. Naylor also obtained a patent for a bent lever, which by constantly changing the fulcrum of the lever acted on by the spring, kept the pressure on the valve nearly uniform.

The valve was made in different forms to overcome various difficulties. By some it was made spherical, with a broad seat, as in the Green Patent, Exhibit B.

(See drawing at end of Brief.)

The valve was also made convex on the inside, and with a rounded rim so that only an edge rested against the valve seat, offering the least surface to adhere or to impede the escape of the steam; or it was made flat and extended some distance over its flat seat, the steam thus having a larger surface to act upon—the first idea of the invention in controversy. The drawings of all the safety valves shown in Cresy's Encyclopædia of Civil Engineering, London, 1847, are reproduced at the end of this brief. Even in connection with the weighted valve, or one having a uniform pressure, there was not a sufficient opening to the valve. The steam at the point of escape being by its escape reduced in pressure below that in other parts of the boiler did not raise the valve to its proper height, and the steam passed out less rapidly than it was generated. Extending the valve beyond its flat seat, as stated above, was first resorted to. The advance on this, viz., the formation of a recess below the extended part of the valve, was made by Waterman, in America in 1853. But this was liable to speedily wear out through the impact of the steam

See Encyclopaedia Britannica 8th ed 1860 Vol 20 p 617.

against the edge of the lip, and the force of the steam being greatest in the direction of its exit this force was largely lost in an impact against the sides of the recess rather than the lip of the lalve. There was no expansive action of the steam in the recess. Green did the same thing in England in 1859. In 1863 Schubert (Beyer) in Germany having the same idea of the employment of the impact of the steam, curved the extended lip downward, but did not make a useful chamber under it, and therefore made no advance on those who preceded him. Naylor curved the extended lip downward over an annular chamber, and at once overcame the defects of the preceding valves, and completed the invention by making use of the expansive properties of the steam.

In 1866, Naylor patented his invention in the United States, and the same year Richardson also took out a United States patent covering the same invention.

"Every great invention is really an aggregation of "minor inventions or the final step of the progression. "It is not usually a creation, but a growth, as truly so "as is the growth of the tree in the forest. Hence, "the same invention is frequently brought out in sev- "eral countries, and by several individuals simultane- "ously." (Prof. Thurston, Popular Science Monthly, Nov., 1877.)

Under our patent laws, Naylor having sworn that he was the first inventor of this improvement, and otherwise complied with the law, and obtained a patent, is entitled to protection.

Properties of Steam.

Steam in its escape through an orifice acts differently from other gases. The pressure of the steam in the containing vessel; its dryness; its units of heat; the pressure and density of the body into which it escapes; the shape of the orifice, and the length of

orifice pipe must all be considered in the investigation of such action.

"Until within the last twenty or thirty years, the "flow of weight and velocity with which steam and "other elastic gases issue through an orifice, were "computed by the same rule which applies to water "or other inelastic liquids. This view was, however, "first, it is believed, demonstrated by Weisbach "to be entirely fallacious, section 1." (Report on Safety Valves. Presented at a meeting of the Institution on October 27, 1874. Transactions of the Institution of Engineers and Shipbuilders in Scotland. Eighteenth Session, 1874–75.)

"According to Mr. Napier's view, the flow is neither "increased nor diminished by reducing the outside "pressure to less than *half* the inside pressure, so that "steam of an absolute pressure of 100 pounds will "pass as fast into steam of 50 as it would into the "atmosphere, or into the best possible vacuum" "(sec. 5, p. 2) *id.*

"After the publication of Mr. R. D. Napier's pam-"phlet the late Professor Rankine was induced to re-"consider the subject, and a very valuable article "from his pen on the 'Outflow of Steam," appeared in "the *Engineer* for November or December, 1869" (sec. 6, p. 2) *id.*

"In that paper Professor Rankine adopts the the-"ory of Weisbach, cancelling only as likely fallacious "the conception to which that theory conducted, of a "reduction of flow being accompanied by every dimi-"nution of the outside pressure below about fifty-"eight per cent. of the absolute pressure in the "boiler" (sec. 7) id.

"According to this hypothesis, which is unques-"tionably very near the truth, the flow is neither in-"creased nor diminished by reducing the outside "pressure below about fifty-eight per cent. of the ab-"solute pressure in the boiler; or, in other words, the "same weight of steam would flow from a boiler under "100 pounds pressure into steam of 58 pounds abso-"lute pressure as into the atmosphere" (sec. 8, p. 2) *id.*

"When steam of 100 pounds pressure flows through
"an orifice, the pressure on the throat of the orifice
"falls to about 57.9 pounds, and the velocity at the
"latter pressure, when the steam has also expanded
"to 1-624 times its initial volume, is 1-624×898=1459
"feet per second" (sec. 15, p, 4) *id.*

"Since an orifice, with a square edged entrance,
"reduces the flow from 12 to 14 per cent. (see
"paragraphs 34 and 37), this allowance will require
"to be made in computing the requisite area, and
"opening of a safety valve, which cannot be considered
"as presenting a much better entrance to the steam
"than a square edged orifice. In making this 14 per
"cent. allowance, the weight in pounds of steam dis-
"charged per minute, per square inch of opening, with
"square edged entrance, corresponds very nearly with
"three-fourths of the absolute pressure in the boiler as
"long as that pressure is not less than 25.37 lbs." (sec.
"55, p. 20) *id.*

"The area of opening, requisite to the discharge of
"any given constant weight of steam, it will be observed,
"is very nearly in the inverse ratio of the pressure.
"Thus while 3 square inches of opening, with square-
"edged entrance, will discharge 3×23 = 69 lbs weight
"of 30 lbs pressure steam per minute, one square inch
"of opening will discharge 67 lbs per minute of 90 lbs,
"pressure steam." (sec 56, p. 21) *id.*

"Before the ordinary valves rise and give sufficient
"opening, the pressure of steam frequently greatly ex-
"ceeds the load under which the valve begins to rise.
"Hence the requirement of *large areas*," (sec. 63, p. 24).

"Safety valves of ordinary construction, if *loaded by*
"*direct weight, do not allow all the steam to escape which*
"*can be raised in the boiler*, until the pressure has in-
"creased above that at which the valve opens, and an
"additional increase of pressure will take place when
"the valves are loaded with springs. That such has
"been the case in the past *by dead weight loading and*
"*imperfectly proportioned valves* is fully illustrated by
"reference to the foregoing experiments," (p. 26, *id.*)
The report from which these selections are taken is

Attention is also called to the article on steam, *Encyclopedia Britannica*, 8*th Ed.*, 1860, vol. 20. This article was referred to by defendant's counsel (*Record*, p. 142, *Int.*, 326):

"All gases and vapors are assumed to consist of numerous small atoms, moving or vibrating in all directions with great rapidity; but the average velocity of these vibrations can be estimated when the pressure and weight of any given volume of the gas is known, pressure being, as explained by Joule, the impact of those numerous small atoms striking in all directions, and against the sides of the vessel containing the gas. The greater the number of these atoms, or the greater their aggregate weight, in a given space, and the higher the velocity, the greater is the pressure. A double weight of a perfect gas when confined in the same space, and vibrating with the same velocity—that is, having the same temperature—gives a double pressure; but the same weight of gas, confined in the same space, will, when the atoms vibrate with a double velocity, give a quadruple pressure. An increase or decrease of temperature is simply an increase or decrease of molecular motion. The truth of this hypothesis is very well established, as already intimated, by the numerous experimental facts with which it is in harmony.

When a gas is confined in a cylinder under a piston, so long as no motion is given to the piston, the atoms, in striking, will rebound from the piston after impact with the same velocity with which they approached it, and no motion will be lost by the atoms. But when the piston yields to the pressure the atoms will not rebound from it with the same velocity with which they strike, but will return after each succeeding blow with a velocity continually decreasing as the piston continues to recede, and the length of the vibrations will be diminished. The motion gained by the piston will, it is obvious, be precisely equivalent to the energy, heat, or molecular motion lost by the atoms of the gas."—*Encyclopaedia Britannica*, 8th ed., vol. 20, p. 562.

submitted with this brief, and it is claimed that under Brown *v.* Piper, 91 U. S., 37, may with propriety be read by the court.

The facts from which these deductions could be drawn are scattered throughout the printed case and the exhibits.

It would take a large amount of the time of the court, however, to collate and sift the data found, from the experiments made, and to distinguish the true from the false.

see Hibbard Ans 19 p 28 Record

Mode of Operation of the Naylor Valve.

When the pressure of the steam in the boiler reaches a certain point, the valve is raised from its seat; the escaping steam impinges against the overhanging lip and is directed downward into the chamber; once in the chamber, the steam expands until the chamber is filled, and in so doing the pressure of the steam is greatly reduced; at its reduced pressure it cannot freely escape from the orifice about the lip of the valve, nor from the opening below the valve; new steam enters the chamber at every instant, as freely as into the air, (ante p. 5,) the pressure increases in the chamber until the extra load upon the valve is overcome; and the valve is lifted so high as to form an opening at the ground joint large enough for the discharge of the steam faster than it is generated in the boiler; the steam at the greatly increased pressure escapes from the orifice about the lip of the valve and from the opening below the valve, (ante p. 6,) being only retarded to such a degree as to retain sufficient pressure in the chamber or recess to hold the valve wide open.

The result is effected by the impinging action of the steam against the overhanging lip, the recoil action of the steam in the chamber, and the throwing an annular sheet of steam upwards around the valve.

The first and second exert a lifting power on the

valve by the impact of the issuing steam, and by the pressure due to the recoil action or expansion of the steam in the chamber; while the third, by carrying the inclosed air upward with the sheet of steam, and cutting off the access of the surrounding air, tends to make a partial vacuum above the valve, and relieves it to some extent, from the atmospheric pressure upon it (Record, pp. 35–160). Now, these operating together, and with the pressure of the steam upon the face of the valve within the ground joint, hold the valve open.

Although it is desirable that it should close when the pressure of the steam in the boiler is reduced to, or slightly below, the pressure at which the valve was set to open, yet it is evident that the valve will not close automatically until the pressure has fallen below that point, or until the sum of the pressure in the boiler and the pressure in the chamber be reduced below that point, or until the boiler pressure has fallen as much as is equivalent to the pressure or force exerted upon the valve outside of the ground joint. It is manifestly important, therefore, to keep the pressure in the chamber at the lowest point consistent with the proper lifting of the valve. And as that is dependant upon the extent of the recoil action, which is determined by the quantity or proportion of the steam escaping below and the density of the steam employed, the openings for its escape must necessarily be adapted to these conditions in each case.

Specification, pp. 6 to 9.

The invention is set forth in the 2d, 3d, and 4th claims, viz.:

"2. The safety valve C, with its overhanging, down-
"ward curved lip or periphery, and annular recess D,
"substantially as herein shown and described, and for
"the purpose set forth.

"3. The annular recess D surrounding the valve-seat
"substantially as herein set forth.

"4th. The combination of the valve C, and the annu-"lar recess D, as herein set forth, and for the purpose "described." (Record p 9.)

The Infringement.

The valve used by defendant is substantially in its construction and mode of operation like that above described.

It differs from it in the size and shape of the chamber and in the opening for the escape of the steam, but these variations are merely formal.

It contains the valve with its overhanging downward curved lip or periphery, the annular recess or chamber surrounding the valve seat, combined for the purpose and operating in the manner described in the complainant's patent. (Hill Record p. 10, Int. 5, and Ans.)

It is impossible to describe its construction and mode of operation by a verbal statement which shall not equally include the Naylor valve as described in the patent. (G. W. Richardson Record, p. 72, Int. 45 to 48, and Ans.)

It is described in the patent of Richardson, Defendant's Exhibit F, pp. 58, 59, in language almost identical with the specification of Naylor's British Patent, dated more than two years before. (Defendant's Exhibit 6, pp. 47, 51.)

Defendant's expert, Hibbard, in answer to cross-int. 26 (p. 28), in describing the mode of operation of defendant's valve, Exhibit 2, states the mode of operation of complainant's valve in answer to the question "If the space through which it escapes freely into the "surrounding air is larger in a valve like Exhibit 2 than "the opening or space at the ground joint, is there any "obstruction to the escape of the steam in point of "fact?" He says, "there certainly is, for two reasons; "first, because steam being indefinitely expansible, in-"stantly fills the space into which it flows with a lower

" pressure, corresponding to the amount of its dilation;
" and second, that the current of steam as it issues
" from the ground joint is broken up in that space,
" and has to again re-form the current to flow out of the
" stricture, offering a resistance to the escape of the
" steam which is measured by the amount of pressure
" *that would be required to force that volume of steam in*
" *its expanded condition through that orifice.*"

The amount of pressure is regulated by the size of the openings through which the steam escapes, and must be varied for the pressure desired to be carried.

G. W. Richardson Record, p. 82, Int. and Ans., 149 and 150. Also int 78 p 75.
(Hot Spring " 162 p 138)

In both valves (Naylor's and defendant's), there is a short space of time when the valve begins to rise, during which the steam escapes freely into the air.

Hibbard, Int. and Ans., 35, p. 31, Record.

In both valves an annular sheet of steam is thrown up around the valve causing a partial vacuum, and relieving it to some extent of the atmospheric pressure.

In both valves the steam is always confined within the recess or chamber outside of the ground joint, no matter how wide the valves open. This is apparent on the inspection of the Naylor valve, the size of the openings being constant. In defendants valve although the width of the structure is variable yet the steam is constantly confined to the chamber. If the valve opens so wide as to allow a perfectly firm egress of the steam, the valve would necessarily, instantly be forced down by the spring until something more should be provided to sustain it, than the mere impinging force of the steam. The force required is the expansion of the steam in a confined space.

Indeed, the defendant admits that Exhibit 2 is substantially like the invention described in said reissued letters patent.

In the answer (p. 4) it says: " That said Wm. Nay-

"lor was not the original and first inventor of the "alleged improvements specified as his invention in "said reissued letters patent; but that on the contrary "thereof, long before any invention thereof by him, "the same were known to and used by Geo. W. "Richardson, of Troy, county of Rensselaer, and State "of New York; Edwin C. Richardson, who now resides "in Poultney, County of Rutland, State of Vermont; "and by Marcus P. Norton, residing in said Troy, and "that the same were known to and used by the three "last named persons at said Poultney."

In support of this, George W. Richardson and Edwin C. Richardson were called to prove that the former, as early as the spring of 1852, made and exhibited to Marcus P. Norton, a drawing or sketch of a valve like Exhibit 2.

Depo. G. W. Richardson, p. 63.
Edwin C. Richardson, p. 89.

Thus virtually admitting that this valve is substantially the same as the invention described in the reissued letters patent, for this is the only kind of a valve besides the common safety valve, either of these witnesses profess to have had any knowledge of, prior to the time of Naylor's invention.

Issues presented by the Pleadings.

These will be considered in their order,

FIRST DEFENCE is (as stated by Judge Shepley).

That the re-issued letters-patent are not for the same invention described in the original letters-patent.

The act of the commissioner in accepting a surrender and granting a new patent is conclusive "unless it is apparent upon the face of the patent that he has exceeded his authority, that there is such a repugnancy between the old and the new patent that it must be held as matter of *legal construction* that the new

patent is not for the same invention as that embraced and secured in the original patent."

Seymour *vs.* Osborn, 11 Wall. 516, pp. 543 and 546

It neither appears on the face of the patent that the commissioner exceeded his authority nor that there is a repugnancy between the old and new patent. *Judge Shepley ignored this defence in his opinion. The defendants' counsel laid no stress on it in his brief, and we would be justified therefore in leaving the question out of our argument.*

We quote a part of the brief of the late Mr. Robb, counsel for complainant, in the Circuit Court, to guide your honors in any investigation of the question you may choose to make:

"The original patent was surrendered to correct a "defective or insufficient claim. That part of the in- "vention covered by the claims of the re-issued patent, "which was not embraced in the claim of the original "patent is described in the specification of both pat- "ents in precisely the same language and illustrated "by drawings identical with each other in the several "patents. The drawings of the re-issued patent being "manifestly tracings of the drawings of the original "patent.

"In both the invention is described in these words: "'A is the main thoroughfare leading directly from "'the boiler; B is a lateral branch or escape passage "'for a portion of the steam after it has passed the "'valve C.

"'I make this valve to project over the edges of "'the exit passage A, and to curve its projecting edges "'slightly downwards, as shown in Figure 1, so that "'the steam, on issuing between the valve and its "'seat, will impinge against the curved projecting por- "'tion of the valve and a portion of it be directed "'downwards into the annular chamber D, surround- "'ing the central passage A, and communicating with "'the exit pipe B, while the other portion of the "'steam ascends past the edge of the valve.'

"The drawings in both patents represent a valve "constructed in conformity with this description; "providing for the escape of *a portion* of the steam "downward from the chamber by the exit pipe and a "portion of it upwards around the edge of the valve.

"In the original patent the *claim* was confined to "the method described of counteracting the load "upon the valve by a bent lever in combination with "the spring. The improvement based upon the pe- "culiar construction, arrangement and combination of "the overhanging lip and annular chamber was not "claimed in that patent, and it was surrendered to "cover the invention embodied in that improvement. "The amended specification must, therefore, neces- "sarily contain a proper reference to that part of the "invention omitted from the original patent, and "which the inventor or his assignee desires to secure "by its reissue.

"The amendment is as follows: 'My invention also "consists in the valve C, constructed with projecting "downward curved lip or periphery, and in the an- "nular chamber D, surrounding the valve-seat, "whereby, as the spring is compressed by the lifting "of the valve, the projecting lip of the valve and the "annular recess are available in causing an increased "pressure on the valve, and thus overcome the in- "creased resistance of the spring due to its compres- "sion, as hereinafter more fully set forth.' (R., p. 7.)

"Also, the 2d, 3d and 4th claims:

"2. The safety valve C, with its overhanging, down- "ward curved lip or periphery, and annular recess D, "substantially as herein shown and described, and for "the purposes set forth.

"3. The annular recess D, surrounding the valve- "seat, substantially as herein set forth.

"4. The combination of the valve C, and the an- "nular recess D, as herein set forth, and for the pur- "pose described.

"Each and every one of which are to be found in "the description and drawings of the original patent.

"Now the amendment contains nothing but what is "verbally stated in the same terms in the specification "of theoriginal patent, except a brief statement of the "effect of the action of the steam in the chamber of the "valve constructed as directed.

"There is nothing, then, open to construction. If "there is anything in the new patent not in the old, it "is the statement of the result which the described "invention is capable of producing, and which may or "may not be true. If not true, it can only appear by "evidence *aliunde;* and if shown to be true, the "patent would be void, because the invention was not "capable of producing the effect described (O'Reilly "*vs.* Morse, 15 Howard, 119), and not because it was

Some attempt seems to be made to claim that the combination shown by Naylor is inoperative, and therefore, although he is the first inventor of the curved lip and chamber, a reissue claiming his invention is void. This is not sound. Where a patent claims a combination of several devices, it may be reissued to claim the devices separately, if new and useful, even though the aggregate combination claimed in the original patent was not by itself useful, or was even impracticable, provided the re-issue points out how the devices separately claimed may be reduced to practical use. (Wheeler *v.* The Clipper Mower and Reaper Co., 10 Blatch., 181.)

"the patent in proper form; and he may, doubtless, "under that authority, allow the patentee to re-describe "his invention, and to include in the *description* and "claims of the patent not only what was well described "before but whatever else was suggested or substan- "tially indicated in the specification or drawings which "properly belonged to the invention,' &c.

SECOND GROUND OF DEFENCE, is (as stated by Judge Shepley):

"That William Naylor was not the original and "first inventor of the improvements specified in said "re-issued patent, but that the same were known to "others, and used by them, as stated specifically in the "answer, prior to the alleged invention thereof by "Naylor."

It was mentioned as known to and used by George W. Richardson, Troy, New York, at that place; by Edward C. Richaadson, of Poultney, Vermot, and by Marcus P. Norton, of Troy; and that same was known to and used by said three last named persons at Poultney.

This point might also be passed over, as Judge Shipley evidently considered it of no weight. It is only mentioned by him as a defence offered by defendant. For the information of the court, if the defence is examined, it may be said that it is not shown that the invention was ever used at Poultney, or at Troy, until the year 1866, three years after Naylor's invention.

The evidence is contained in the depositions of Geo. W. Richardson and his brother, E. C. Richardson, which only show that in the winter of 1851 & 2 the former made some drawings and sketches of a safety-valve; in the spring of 1852 made a sectional model of it cut out of veneer; in 1853 turned a model in wood, and in 1866 made the first valve and obtained a patent for it Sept. 25th, 1866.

Dep. Geo. W. Richardson, p. 63.
E. C. Richardson, p. 89.

These circumstances are not sufficient to defeat this patent. There is not the slightest evidence that Richardson used any diligence whatever to perfect the invention, or reduce it to practice until more than two years after Naylor had obtained his patent for it.

He pretended that he was prevented by poverty; but he bought, owned and sold real estate during that period; was employed nearly, if not quite, all the time,

at his trade, either as machinist, foreman, or superintendent of a machine shop, on wages ranging from $600 to $1,000 a year. It is preposterous to say, that from 1851 to 1866, nearly fifteen years, he had not means to make a working valve, or an opportunity to test it.

Record, p. 68–69, Ans. 1 to 10; —— 77, Ans. 90 to 112.

THIRD GROUND OF DEFENCE is (as stated by Judge Shepley) "*that the reissued patent does not cover and embrace the valve used by the defendant.*"

This defence is not consistent with the other defences. If Richardson was the inventor (as set forth in the second defence) of the improvement shown in Naylor's patent, and the improvement which he invented is shown in the valve of defendant (dep. of G. W. Richardson, p. 63, Int. and Ans. 1), Naylor's reissued patent must cover defendant's valve..

Judge Shepley would have been of the same opinion we believe if he had found the state of the art different. He says:

"*From the history of the art, as previously given*, and "from a comparison of the original with the reissued "Naylor patent, as well as from the language of the "claim in the reissued patent, it is manifest that if "these claims can be sustained it can only be for the "combination of the described valve, with its over-"hanging downward curved lip, with precisely such an "annular recess surrounding the central chamber as "he describes. *Naylor did not invent the overhanging "downward curved lip or periphery*, nor was he the first "to use *an annular chamber surrounding* the valve seat "into which a portion of the steam is deflected as it "issued between the valve and its seat. His claims "must, *therefore*, be limited to the combination of the "other elements with *precisely such an annular recess* "as he has described, and operating in the described

" manner so far as such recess, separately or in combi-
" nation, differed in construction and operation (*if it*
" *did materially differ in those respects*) from those which
" had preceded it."

The only other overhanging downward curved lips or peripherys in the evidence are shown in the patents of Beyer and Richardson. The latter is two years later in date than Naylor's English patent.

Judge Shepley, therefore, evidently refers to the Beyer patent.

The Beyer patent is of a later date than Naylor's invention, and ought not to have been considered by Judge Shepley.

In order to understand why we claim Naylor's invention to be earlier than Schubert's (Beyer) when Naylor's English patent is dated July 21st, 1863, and Beyer's English patent is dated April 25th, 1863, it is necessary to detail at length the English practice in granting patents. Our authority is the work of William Fischer Agnew on "The Law and Practice Relating to Letters Patent for Inventions," London, 1874:

" The first step for an applicant for letters patent to
" take is to petition the crown for a grant. The peti-
" tion states that the petitioner is in possession of an
" invention (naming it) that he believes it will be of
" great public utility; *that he is the first and true invent-*
" *or;* and that it is not in use by any other person, or
" persons, to the best of his knowledge and belief."

Id., p. 141.

The petition is accompanied by a solemn declaration with the same recital in support.

" The petition and declaration are then left at the
" office of the Commissioner. There is also left at
" the same time a statement in writing called a pro-
" visional specification, signed by or on behalf of the
" applicant, describing the nature of the invention.

Id., p. 142.

"The provisional specification must state distinctly "and intelligently the *whole nature of the invention*, so "that the law office may be apprised of the improve- "ment, and of the means by which it is to be carried "into effect."

Id., p. 143.

"If the law officer is satisfied that the provisional "specification describes the nature of the invention, "he will allow it, and give a certificate of his allow- "ance, which is filed in the office, and the invention is "then protected for the term of six months from the "consequences of use and publication."

Id., p. 143.

"Where any invention is provisionally protected "under the act, or protected by the deposit of a com- "plete specification, the commissioners are to cause "such protection to be advertised, the advertisement "will be in the *London Gazette*, and sets forth the "name and address of the petitioner, the title of his "invention, the date of the application, and, in the "case of a complete specification, that such has been "deposited.

"As soon as he thinks fit, after the foregoing steps "have been taken, the applicant may give notice at the "office of commissioners of his intention to proceed "with his application, the commissioners then cause "the application to be advertised. Any person having "an interest in opposing the grant may leave particu- "lars of their objections to the application as follows. "The notice of intention to proceed is advertised in "the *London Gazette*, and the advertisement sets forth "the name and address of the petitioner and the title "of his invention; and that any persons having an "interest in opposing such application are to be at "liberty to leave particulars in writing of their objec- "tions to the application, at the office, within twenty- "one days after the date of the *Gazette* in which the "notice is issued.

"The notice of the applicant's intention to proceed "must be left at the office eight weeks before the ex-

"piration of the term of provisional protection, and
"no notice to proceed may be received unless the same
"has been left in the office eight weeks at the least,
"before the expiration of such provisional protection."

"After the time for delivery of such objections shall
"have expired, the provisional specification, or com-
"plete specification, and particulars of objection, are
"referred to the law officer to whom the application
"has been referred."

Id., pp. 154, 155.

"After the hearing, the law officer may cause a war-
"rant to be made for the sealing of letters-patent.

Id., p. 155.

This being the practice of the Patent Office, there is no evidence that Schubert's invention was described in any printed publication *anywhere* previous to July 21st, 1863.

It was not patented until October 16, 1863, the date of sealing of the ante-dated patent.

Smith *v.* Goodyear Dental V. Co., 11 O. G., 246, 249.

It was not printed until after the latter date. This is the practice of the English Patent Office, and is evident from the inspection of the copy of the patent in evidence.

Naylor had made his invention previous to July 21, 1863, the date of filing his petition, declaration and provisional specifications. He should not be compelled to take the date of issue of his patent or that of his invention. The only fair supposition is that when he first applied for a patent his invention was complete. This supposition is supported by the practice of the English Patent Office, which requires that the invention, as shown in the two specifications (provisional and complete), should be one and the same.

Agnew, p. 151.

It is also supported by the language of the provisional specifications (Record, p.), which is a sufficient description of the invention to fix its date, at

least as early as the date of filing of the provisional specification. Naylor's invention, then, being before the patenting or publication of Schubert's (Beyer), and Naylor having made oath that he believed himself to be the first and original inventor in his application for a re-issue, the *Beyer* patent must be left out of the case.

Bartholomew *v.* Sawyer, 1 Fisher, 516.
Smith *v.* Goodyear Vul. Co., 11 Off. Gaz., 246, 249.

Judge Shepley's conclusions, therefore, fall with his premises.

We think this point conclusive. If it is not so held by the court, the further point may be made that the Beyer patent is not for the same invention as that shown in the Naylor.

Beyer only carried forward the invention of Green, so far as the use of the impinging force of the steam was concerned, by curving downward the straight lip of Green's valve. That Beyer did it for this purpose is evident from the language of his specification.

"When the steam begins to escape from between "the surfaces of the valve, it gets between the concave "and convex surfaces of the two flanges, and its force "thus acts upon a larger area, and reacts upon the "concave surface of the valve, and causes it to open to "a greater extent than the ordinary safety valve.

Nothing is said of the expansive force of the steam. The sentence means that the impinging force of the steam causes the valve to open to a greater extent. This is sustained by examination. The verb *react* is intransitive and defined by Webster as follows:

"1. To return an impulse or impression; to resist "the action of another body by an opposite force; as, "every body reacts on the body that impels it from its "natural state.

"2. To act upon each other, to exercise a reciprocal "or reverse effect, as two or more chemical agents."

see also Hubbard ans 34 p 30 Record

The language of the specification is sustained by the facts.

Defendants' expert, Hibbard, made an experiment with a Beyer valve and found "with the Beyer valve "put in the same place, it commenced to blow off "steam slightly at 80 lbs.; and in one instance, when "the pressure had increased to 85, the valve 'pop-"ped,' when the pipe communicating *with the upper "lip showed a pressure of* 8 *or* 9 *lbs.* at its greatest "height, varying from that to less, *and the pressure on "the lower lip showed a vacuum of from two to three "pounds.* * * * Although in the Beyer valve the "opening between the lip and seat at its outer extremity "is somewhat narrower than it is near the ground "joint, it does not appear to be enough, nor the cham-"ber within the structure large enough to act as the "valve and stricture act in opening the valve suddenly, "and holding it open so wide as to reduce the pres-"sure in the boiler below the point at which it "opened."

Record, pp. 147 and 148.

Defendants' witness, Waters, says in his examination: "There is a lip upon that valve (Beyer), but it is so "formed and arranged in relation to the ground joint "that it does not receive and destroy the impinging "force of the jet of steam, but it does little more than "deflect that jet, the main force of the jet still con-"tinuing outward after it leaves the lip, as has been "abundantly proved by the experiments to which I "have testified with regard to that valve where the "steam issued through the ground joint at a speed due "to a pressure of ninety pounds to the square inch, "and yet produced an actual pressure upon the lip of "only about eight pounds."

Record, p. 162, old record, p. 270.

The defendant has destroyed its own reference as to priority by its own witnesses.

In the Beyer patent there is only a thin annular space into which the steam flows when the valve opens.

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In the Beyer patent there is only a thin annular space into which the steam flows when the valve opens.

During the time the steam is passing this space, there is never confined in the space such a volume of steam as to be of any service by expansion in assisting the valve to open any higher than an ordinary safety valve. Cambridge Record, p. 144. Blanchard p 101. 102 Int 13 & 14

In the Naylor valve there is a chamber below the lip of the valve into which the steam is directed by the lip of the valve, and in this chamber the steam is of SUCH VOLUME and so confined that it has the same relative power due to its expansion as in the cylinder of an engine.

STRICTURE.

Much confusion has been sown in this case by the use of the word "stricture." This word means in medicine the contraction of some duct or passage. (Webster and Worcester.) Such is its meaning in *medicine*, not elsewhere. Richardson (p. 73, Ans. 49), says that by stricture he means "the space be- "tween that portion of the valve and the edge of the "seat where the steam issues into the open air in "leaving the annular space or chamber. I call it a "stricture because it obstructs the free passage of the steam between the annular space and the open air.' Record, p. 73, Ans. 49.

When asked what proportion the size of that space must bear to the size of the space from which the steam issues at the ground joint to make it a "stricture," he answers: "Any proportion which will cause "a pressure in the annular chamber." Record, p. 73, Ans. 50.

Now, it makes no difference what the shape of the orifice is, whether round and at one side, as in Naylor's drawing, or encircling the valve, as in defendants' valve, in either case the exit is to be made of the "pro- "portion which will cause a pressure in the annular "chamber," and is to be altered to suit the case. Record, p. 76, Ans. 88.

If a long exit pipe is used, of course the diameter of the exit must be larger than though a short pipe were used; because, in the long pipe the steam is greatly retarded by its friction against the sides of the

pipe. If the opening is circular about the valve, it must be narrower when used without than when used with an outer rim to turn up the steam; because in the latter case the steam is retarded by its friction against the outer rim. For different springs different orifices are required (p. 76, Ans. 88). These facts are well known to a competent mechanic, and the principle once being given these modifications are only a matter of mechanical skill. Record p. 76. Ans.

But it is said that the "stricture" in defendant's valve is variable. This is no advantage. The steam escaping from the ground joint is immediately reduced in pressure by expansion; in its expanded state it cannot escape at the opening, and consequently exerts its force against the lip of the valve, and thus assists in raising it higher. Now, the wider the valve is opened the greater the overflow of steam into the annular chamber, and the less its expansion there; it, therefore, can escape through the orifice which was an obstruction to that of a lower density. The boiler, is thus relieved through the orifice which serves to retain the escaping steam. The orifice from the chamber, then, if of the proper size (and this varies in each case according to the size of the boiler grate surface, pressure carried, &c.), may remain stationary. In both complainants' and defendant's valves, properly constructed, the escape of the steam is always hindered so as to make its expansive force available.

Record, p. 73, Ans. 50; p. 31 [illegible] 46

The action of defendants' valve is the same as that of Naylor *i. e.*, the steam is deflected as it escapes from the valve by an overhanging lip into an annular chamber, and there is partially confined by the impediment offered to its escape, and on expanding it presses against the lip, adding thus several pounds pressure to that of the steam within the boiler on the valve, and so lifts it higher. It must be remembered that the area acted on by the steam outside the valve is much greater than inside. Record, p. 118, Ans. 143. And the pressure thus obtained though slight as compared with the boiler pressure is large in fact.

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EXHIBIT G.

Rubber Co v Goodyear
9 Wall 793

There is no allegation in the pleadings proper to sustain evidence that the valve shown in complainant's patent is inoperative, and that therefore the patent is void. A large amount of testimony however was taken to this end. It must therefore be presumed that it was only introduced for the purpose of limiting the claims of Naylor to some valve other than that which he and we have described: claims which would not cover defendants' valve. For this purpose we presume Exhibit G. was introduced. This is a false and misleading valve.

The witnesses *assume* it to be or are told it is the Naylor valve. This valve was subjected to a series of tests in the presence of witnesses, who made memoranda, to swear by when called upon to institute comparisons between the two valves in giving their *expert* testimony in the case. Their testimony, together with that which it necessitated, covers more than one hundred and sixty seven pages of the original record, not one line of which would have appeared in the case, if that Exhibit G had been constructed in conformity with the full, clear, and unmistakable directions and descriptions contained in the specification and illustrated by the drawings of the patent.

Now the very essence of Mr. Naylor's invention is that the steam sould *recoil* in the chamber. In the specification of the reissued and original patents he says, I make this valve so that a portion only of the steam "shall escape below, and a "portion escape around the edge of the valve,"—the necessary effect of which is to cause a recoil action in the chamber, and thus produce the desired increased pressure on the valve.

In the specification of the reissued patent he distinctly says that, constructed in the mannner shown "the projecting lip of the valve and the *annular recess* are available in causing an increased pressure on the

valve, and *thus* overcome the increased resistance of the spring due to its compression," &c.

In the English patent, which the defendant has put in evidence (Defendant's Exhibit C), after describing the construction of the valve, in the very terms of the specifications of the original and re issued American patents, he says: "By this means I am enabled to avail myself of the *recoil action* of the steam against the valve, for the purpose of facilitating the *further* lifting of *such* valve when once opened" (p. 49).

In the provisional specification, which is a part of the same Exhibit, he describes the contemplated action of the steam in these words: "This invention * * * consists in the employment of valves," * * * "having the edges of the valve outside the valve seating cupped, or turned downwards, so that the main body of the steam as it escapes from the boiler being directed downwards, strikes against the bottom of a suitable recess, or into a chamber round the pipe leading from the boiler to the valve, and *consequently* the recoiling action of the steam acts upwards against the under surface of the valve as it issues forth into the atmosphere, and by such recoiling action of the steam the valve is assisted in opening," &c.

It is obvious to any one, and without experiment, more especially of that class to whom these specifications are addressed, that "Exhibit G" does not contain any provision for the escape of any portion of the steam upwards. On the contrary, it is so constructed that the *whole* of the steam will necessarily be discharged below at the exit pipe without any obstruction whatever. Thereby not only preventing any recoiling action of the steam in the chamber, but creating a vacuum under the lip of the valve—loading it with an increased atmospheric pressure of several pounds to the square inch (Record, pp. 137, 138); and it is equally obvious, that if it were so constructed, that a portion only of the steam could be discharged by the exit pipe, and a portion around the edge of the lip, the steam *must* recoil in the chamber—producing the desired upward

pressure under the valve—and that the annular sheet of steam flowing upwards around the lip, would carry with it the enclosed air, and *relieve* the valve of atmospheric pressure, as suggested, indicated and directed in the Naylor specification.

It is conceded by all the experts that the effect will be the same in the operation of the valve, or upon the action of the steam in the chamber, whether the proportion to be discharged by the exit pipe be determined by the size of the discharge pipe employed, or by contracting the openings at the radial bars, or by openings through the bottom of the recess. The examination of Mr. Hibbard, the leading witness for defendant, on this subject, on p. 33, is as follows:

Cross-Interrogatory 57. I would call your attention to Exhibit G, which you have testified represents the Naylor value, as you understand its construction. Please state whether a portion of the steam, which passes into the annular chamber surrounding the valve seat, cannot be made to escape through the space around the lip of the valve without altering the principle of the operation of that valve, as you understand the principle of its action.

A. It cannot, so far as I can see.

Cross-Interrogatory 58. Please explain your meaning by the words "so far as I can see?"

A. I simply meant to say that I could not see how the valve could operate as suggested in the interrogatory without substantially changing the principle and character of its operation.

Cross-Interrogatory 59. Would not a portion of the steam escape from that annular chamber, by the opening around the lip of the valve, if the passage between the upper and lower part of that chamber at what you call the radial arm, were contracted?

A. It would if the passage were contracted sufficiently.

Cross-Interrogatory 60. Then if you were requested to construct a valve of that description, so that a portion, say one-half, of the steam which passed into

that chamber should escape by the opening around the lip you would not construct it, so far as the interior of that chamber is concerned, like that valve, Exhibit G, before you, would you?

A. I should not, so far as the size of the openings between the radial bars is concerned.

Cross-Interrogatory 61. The passage of the steam in that case would be so far obstructed as to cause a portion of it to be thrown back or upwards towards the opening around the lip, would it not?

A. It would if the openings were made small enough.

Cross-Interrogatory 62. You would make them small enough, wouldn't you, if you intended that a portion of the steam should escape through the space around the lip?

A. I should either do that or obstruct the escape-pipe in some other way.

Cross-Interrogatory 63. And the force of the steam escaping through the space around the valve would be dependent, in some measure upon the size of the opening that you would make below, would it not?

A. It would.

Cross-Interrogatory 64. Would not the steam which passed into that chamber from the ground joint expand in that chamber; I mean the chamber when in the condition stated in the preceding interrogatories with the opening below so contracted as to cause the desired portion of the steam to escape by the opening around the lip?

A. It would.

Cross-Interrogatory 65. Is Exhibit G the Naylor valve, so called by you, so constructed that the projecting lip of the valve and an annular recess are available in causing increased pressure on the valve?

A. There is some increased pressure upon the valve, but the annular chamber has no part in producing it. But the pressure so produced, is not, in my judgment, for any useful purpose.

One reason for this is, that the escape-pipe of Ex-

hibit G for the discharge of steam is many times larger than is necessary even for the discharge of all the steam as fast as it issues from the boiler; its area being much larger in proportion than that of the drawing in Naylor's patent.

All the original evidence offered by the defendant to support this defence, that is, that the valve used by it is not covered by complainant's patent, consists in the opinions of two or three witnesses, based upon this factitious standard.

Dep. W. G. Hibbard, pp. 38, 39, Ints. 16, 17, 18.

Dep. G. W. Richardson, p. 109, Ints. 17, 18.

The fallacy of the assumption involved in these opinions is fully exposed by Mr. Blanchard, a witness of large experience as one of the principal examiners in the Patent Office many years, having charge of the class of steam engines, embracing all the devices in which steam is generated and used, also the class of hydraulics, pneumatics, and hydrostatics.

Dep. J. M. Blanchard, pp. 156 to 166, Ints 1 to 9; pp. 169 to 172, Ints. 15 to 17; pp. 228 to 231, Ints. 300 to 307.

Defendants became dissatisfied with their Exhibit

There was no escape pipe used with this exhibit. Such a pipe or an equivalent is necessary and has always been used to prevent the steam interfering with the engineer. Record, p. 91, Ans. 11,

See Exhibit T., last drawing annexed.

The drawings of Naylor's patent shows a flange to which a pipe is to be annexed.

(This testimony was objected to, and no cross-examination made.)

Mr. Waters also testified at about the same time in another cause using this exhibit Hibbard, Naylor model (Record, p. 151). (This testimony was admitted under a stipulation which does not seem to have been complied with.) He says in reference to the exhibit: "This exhibit was made at my suggestion, I "believe, and it was made for the purpose of testing "the mode of operation of the Naylor valve such as "is referred to in the re-issued patent to Ashcroft, and "the instructions were to make it exactly like the "drawings as near as possible, and I believe it is so "made." The witness does not seem to have made any examination for himself of the size of the valve, neither to have used any discretion in its manufacture, as he indicates is necessary at p. 176, ans. 105 and 106 of his examination, and at p. 181, ans. 123.) The same objections that have been made to exhibit C, apply to this exhibit. Defendant based his testimony at the commencement of the case on a false exhibit, this can no more be trusted. Mr. Richardson says that the difference of a thousandth of an inch at the opening of his valve will make a difference in the operation. Defendants experts therefore, appear rather to have made exhibits to defeat the patent than to ascertain its mode of operation.

A false and misleading experiment was made by closing the exit below the overhanging lip entirely, and in that condition the valve would not close even with a spring directly over it.

Hibbard, pp. 59, 60, 61, Ans. 29,30, 31, 32. Waters p 176

The argument was presented by defendants' counsel in the court below, that Naylor's use of a lever to equalize the pressure of the spring is a proof that Naylor did not intend what he says in his patent. This is absurd. Beyer extended the lip of his valve which was held down by a *constant* weight, and at the same time mentions the reason, which defendant says is good in that case.

Again, defendant's counsel says (p. 6, brief below):

"The common safety-valve does not lift or blow off "the pressure freely until the pressure has increased "to a considerable extent above the pressure fixed "upon. This is doubtless due to the fact that after "the steam has begun to escape from the common "safety-valve, the pressure under the valve cannot in- "crease, the mere act of the steam in escaping pre- "venting such increase."

See p. 6, ante.

It was then necessary for Naylor to have something in addition to his lever arrangement to open the valve wider than the common lever safety-valve would open, and he got this by his overhanging lip and chamber, by which he made use of both the expansive and impinging force of the steam.

FOURTH GROUND OF DEFENSE is (as stated by Judge Shipley),

"That the valve used by defendants is described "and contained in letters patent of prior date to com- "plainant's invention, granted by the British Govern- "ment to Thomas Green, also to Charles Beyer, and "by the United States to Henry Waterman, and also "to George W. Richardson; and that the invention "of George W. Richardson, described in his patent, "was made prior to the invention of Naylor set out in "the bill."

We will consider the references in the order of time.

WATERMAN'S PATENT (see Drawing at end hereof and Record, p. 51).—The original patent was granted in the United States Nov. 15, 1853, and contains no mention of any device for increasing the lift of the valve by the agency of the steam itself. The whole specification is given up to the description of a lever safety valve so arranged that the valve will not be

lifted by the jolting of the boiler. The evils of springs are descanted upon.

This patent was reissued July 9, 1867 (after the Naylor and Richardson patents had both been issued) to cover the invention in controversy, and, curiously enough, Geo. W. Richardson, the reputed inventor of the Richardson valve, is a witness to the reissued specification. He was not so sure at that time that he was the first discoverer of the useful employment of the expansive force of steam by means of a chamber or rim surrounding the valve.

There is nothing to show that Waterman ever sought to employ the steam escaping from his valve, expansively; or that his experiments resulted in any discovery which he put the public in useful and practical possession of in the form of a machine so described as to be understood. Curtis on Patents 3rd ed. sec 378 a Seymour v Osborne 11. Wall 55 Richardson v Noyes 10. OG 597

GREEN'S PATENT.—This patent was granted in England, dated May 9, 1859. (See drawing at end hereof, and Record, p. 44, &c.). It resembles the Waterman valve in its action. This is stated in the specification in these words: "Figure 5 shows a safety valve and "apparatus constructed and combined according to "another part of my invention; *l* is a valve having a "spherical under surface; *m* is a disc of larger diame- "ter than the valve, so that any steam escaping beyond "the valve will tend to press the disk and valve up- "wards; *n* is a cup, the upper edges of which rise "somewhat above the disc, and there is a small space "below the inner surface of the cup and the outer edge "of the disc. * * * I would state that the pecu- "liarity of this part of my invention consists in "the continuation of the parts *l*, *m* and *n*, as "herein described." There is nothing in the specifications to show that Green had any idea of the use of the expansive force of the steam in an annular chamber surrounding the valve. An inspection of the drawing shows that the valve and disc are improperly constructed for the purpose

of making use of the expansion of the steam. The deep space cut under the disc and over the valve, would almost neutralize the expansive effect of the steam.

No knowledge of the invention in controversy was given to the world by this patent.

Defendants' expert, Hibbard, says of the lip of this valve, Ans. 11, p. 21: "This surface is not curved "downward, and is not so placed in reference to the "ground joint, that the steam would impinge against "it so as to act in any degree by its momentum."

BEYER'S PATENT.—It is curious that in the argument of this cause in the Circuit Court the date of this patent was entirely overlooked.

The Beyer patent was sealed on the 16th of October, 1863.

This is the date of the patenting of the invention abroad within sections 4886 and 4920 R. S.

The provisional specification for said patent, filed April 25, 1863, was not printed until the printing of the completed specification which it accompanies. The completed specification was filed on October 21st, 1863.

The provisional specification of Naylor was filed on July 21, 1863. It contained a description of Naylor's invention, showing in apt words what his invention was., viz.:

"This invention relates to certain improvements in "safety valves, and consists in the employment of "valves (when used with levers loaded by dead "weights), having the edges of the valve outside the "valve seating cupped or turned downwards, so that "the main body of the steam as it escapes from the "boiler, being directed downwards, strikes against "the bottom of a suitable recess, or into a "chamber round the pipe leading from the "boiler to the valve, and consequently the recoil-"ing action of the steam acts upward against the "under surface of the valve as it issues forth into the

" atmosphere, and by such recoiling action of the " steam the valve is assisted in opening so as to coun- " teract the resistance of the atmosphere to the issuing " steam, which resistance is virtually equal to an " extra load on the valve; or the edges of the valves " may project horizontally beyond the valve seat, so " that the steam, after leaving the valve facing may " act under the projection as it rushes into the atmos- " phere, virtually acting on a larger valve surface after " leaving the boiler and before its final exit into the " atmosphere."

Defendant's witness, Waters, could not see any difference between this and the completed specification afterwards filed.

Record, pp. 2 and A. 19.

Naylor's invention must therefore have been made before July 21st, 1863, and therefore before the patenting or publication of that of Schubert (Beyer). Beyer's patent cannot, therefore, be made to anticipate Naylor's invention.

See further discussion of this point ante, p. 19, and as to disclaimer in subsequent specification, post, p. .

At p. 20, ante, we also attempted to show that the Beyer patent was not for the same invention as that shown in Naylor's reissued patent.

RICHARDSON'S PATENT.—It is not proper to introduce evidence that defendant's valve was constructed under another patent, or to bring up this other patent at every turn, as in this case.

" It is no answer to the cause of action to plead or " prove that the defendant is the licensee of the owner " of another patent, and that his machine is construct- " ed in accordance with that patent."

Blanchard *vs.* Putnam, 8 Wallace, 420.

As the words of the answer " And that the invention " of George W. Richardson, described in his patent,

" was made prior to the invention of Naylor set out in " the bill " are only a repetition of the second defence, we refer to our argument on that defence at page 15.

The validity of Richardson's patent is not in controversy in this suit.

The attention of the court is also called to the fact that the valve used by defendant has an encircling rim affecting the working of the valve materially, which is not shown or claimed in the Richardson patent.

STILL ANOTHER DEFENCE was attempted to be introduced on the argument below, viz., that Naylor, an alien, had failed and neglected, for the space of 18 months from the date of the patent, to put and continue on sale to the public on reasonable terms his invention. ~~This is not in the answer, and, therefore, cannot be admitted. But if it could be so admitted,~~ It is not a defence, as it is not necessary under the statute for an alien patentee to prove that he hawked the patented invention to obtain a market for it, or that he endeavored to sell it to any person. It rests on those who seek to defeat the patent to prove that the patentee neglected or refused to sell the patented invention for reasonable prices when application was made to him to purchase.

Tatham *v.* Fowler, 2 Blatch., 49.

ASSIGNMENT OF ERRORS.

The court below erred.

1st. In giving weight to the disclaimer of Naylor in his English patent.

2d. In deciding that because of the Beyer patent Naylor must be limited to claims for a " combination of " the described valve with its overhanging downward

"curved lip, with *precisely such an annular recess* sur-
"rounding the central chamber as he describes," or as stated further on in the same opinion: "To the combina-
"tion of the other elements with precisely such an annu-
"lar recess as he has described, and operating in the de-
"scribed manner so far as such recess separately or in
"combination differed in construction and operation
"(if it did materially differ in these respects) from
"those which preceded it."

3d. In deciding that, "Naylor did not invent the
"overhanging downward curved lip or periphery, nor
"was he the first to use an annular chamber surround-
"ing the valve seat into which a portion of the steam
"is deflected as it issues between the valve and its
"seat."

4th. In deciding that the defendant's valve was not within the re-issued Naylor patent.

5th. In deciding that "there is a substantial differ-
"ence between the defendant's valve (Richardson)
"and the valve in the specifications and drawings of
"the Naylor patent *not merely in degree.*"

We have already gone over the ground covered by these errors, and tried to show that although the reasoning of Judge Shepley may have been right, his premises were wrong, and that on a most material point entirely omitted in the consideration of the case in the court below.

We shall partially review the case with reference to each of the errors assigned.

First Error.—Giving undue weight to Naylor's disclaimer in his original patent. We have already (p. 17) given the English practice in granting patents. To understand why Naylor made the disclaimer in his complete specification of that previously claimed in

the provisional specification, it will only be necessary to continue the recital of the English practice.

It was stated that the petitioner had six months after filing his petition and provisional specification within which to apply for his patent (or give notice to proceed as it is called).

"When a provisional specification is left and pro-
"visional protection thus obtained, there is nothing to
"prevent another provisional specification for a similar
"invention being left."

Agnew, p. 149.

Both Beyer and Naylor left provisional specifications at the Patent Office. That having been done, it was simply a race of diligence (there being no fraud), as to who should get a patent *first*, and hold the invention. Either party could have proceeded at any time within the six months, and the one who proceeded would have obtained the patent.

Agnew, p. 149.

But both waited the six months allowed by law, showing that neither had suspicion of the other's invention.

Beyer obtained his patent first as an introducer into the Kingdom. After that, Naylor was absolutely shut out from obtaining a patent, if his invention was the same. When a patent has actually been sealed, the Crown will not afterwards enter into the question whether or not some one else who had previously applied was a prior inventor, *and will in no case give a subsequent grant for the same thing for which a patent had already been granted.*

Ex parte Bates & Redgate, 8 R., 4 ch., 517.

Ex parte Henry, 8 R., 8 ch., 167.

The Crown would not therefore, had there been a contract, have given Naylor a grant for the same thing previously granted to Beyer. There does not appear to have been any contest over the application of Naylor.

There is another rule of law, which, if Schubert's (Beyer) and Naylor's invention was the same, rendered the disclaimer necessary—*i. e.*, if a patentee claims that which is old together with that which is new, the whole patent is void, the new sharing the fate of the old.

Carpenter *v.* Smith, 1 Webs.' Pat. Cas., 540, 532.

We think, therefore, that in view of these facts, and that in the specification of Naylor's original American patent no disclaimer was inserted, and that on the grant of the re-issue an oath of invention was taken, undue weight was given to the disclaimer in the English specification. It was merely the work of an agent patentee who supposed he had found an anticipation of Naylor's invention, and therefore desired by the disclaimer to save the other inventions shown. This is supported by the fact that the provisional specification claims the invention broadly.

The disclaimer created no estoppel.

Allen *v.* Blunt, 2 Wood & M., 143.

A disclaimer may be withdrawn on re-issue.

Daniels *vs.* Chesterman.

Dec. of Com. of Pat., 130, G. 4.

Kenney v Bradley 2 Fish 362

Second Error.—That in view of the Beyer patent Naylor's claims must be limited as specified.

We have tried to show, at page 17, that the Beyer patent could only be considered in the light of a more recent patent or publication than Naylor's invention, also that Beyer's patent was not for the same thing. If the court agree with us this decision of Judge Shepley's is clearly erroneous.

Third Error.—That Naylor did not invent the overhanging downward curved lip, or periphery, or the annular chamber surrounding the valve seat.

If the Beyer patent is rejected there is not one syllable of testimony left to show that Naylor was not the inventor of the overhanging lip, excepting that of Richardson. But Richardson never made a valve until

1866, two years after the date of Naylor's English patent. As between two rival inventors, therefore, Naylor is prior.

The same may be said of the annular chamber into which a portion of the steam is *deflected* as it issues between the valve and its seat.

It cannot be said of the Green or Waterman valve that the steam is *deflected* into an annular chamber. In either of these valves the steam escapes upward into an annular chamber above the valve without *deflection*. It is this deflection which utilizes the impinging force of the steam; the impinging force of the steam is exerted in the direction of its escape. In the Naylor valve the direction of the escape of the steam is towards the curved lip; in the Green and Waterman valve towards the sides of the chamber.

But Judge Shepley did not base his decision on these valves.

Fourth Error.—That defendant's valve is not within the Naylor patent.

The decision of Judge Shepley so hangs on the Beyer patent, that with this left out (as before argued) it is all error.

This error is merged in the next.

Fifth Error.—That the difference between the Naylor and defendant's valve (erroneously called Richardson's) is more than one of degree.

The comparison between the valves is unfairly made, unless the disclaimer of Naylor is given weight.

Judge Shepley says: "In the Naylor valve it appears "that it was the intention of the inventor to use the "impact of the issuing steam upon the concave lip of "the valve to assist in lifting it, *and only this*, except "so far as it was aided by the diminution of atmo- "spheric pressure on the top of the valve. * * * * "the annular chamber into which the steam is dis-

" charged on leaving the valve *serves no other purpose* " *than that of a conduit of the steam*, when the valve is " constructed in accordance with the drawings in the " original patent." This is contrary to the statement of Naylor in his English Provisional Specification which says that his invention consists in the employment of valves " having the edges of the valves out- " side of the valve seating cupped or turned downwards, " so that the *main body of* the steam as it escapes from " the boiler being directed downwards, *strikes against* " *the bottom of a suitable recess*, or into a chamber round " the pipe leading from the boiler to the valve, and " consequently THE RECOILING ACTION OF THE STEAM " ACTS UPWARDS AGAINST THE UNDER SURFACE OF THE " VALVE as it issues forth into the atmosphere, and by " such *recoiling action of the steam the valve is assisted in* " *opening*."

Again, he says in his specification, after describing the curved lip and chamber shown in the drawing, " By this means I am enabled to avail myself of the " *recoil* action of the steam against the valve, for the " purpose of facilitating the further lifting of such valve " when once opened."

The re-issued American patent is also explicit, and if a valve was made according to it, so that part of the steam should escape upwards around the lip, the "annular chamber into which the steam is discharged, on leaving the valve," would be "a conduit of the steam," but a restricted conduit, acting in precisely the same manner as the restricted conduit (chamber) of the defendant's valve.

Judge Shepley was led into this error by the false construction of Exhibit G. The properties of steam escaping through an orifice were not brought out by complainant's counsel on the cross-examination of Hibbard. One need not be a mechanic to know that that exhibit is false. It appears by the testimony that the double sized valve is double in lineal measure only. Not a witness swears that a mechanic acquainted with the properties of steam, if called on to make a two-

inch valve like the inch valve of Naylor's drawing, would make the escape double the diameter of that shown in the drawings. It is well known that orifices for the escape of liquids and gases are measured not by their diameter but by their area. If two orifices are given to be enlarged proportionally, the diameter of each would not be taken as a guide, but the *area* of the openings.

See Blanchard's Ans., 8 R., p. 98.

After the testimony had been closed, on an order of the court, the witness Hibbard, who had testified as to the correctness of Exhibit G, was called again, and testified as to experiments with a valve made of the size of the drawings. This valve worked the same as Exhibit G. Richardson swears that the one thousandth of an inch in the width of the stricture makes a difference in the action of his valve. Hibbard testifies at p. 42, that the capacity of the stricture, is a matter easily adjustable in the manufacture, for the purpose of regulating the pressure at which the valve is desired to close. Yet there appears to have been no effort made to make this valve work. It was constructed of the size of the drawings and that was all. No judgment was used.

Complainants' witnesses made several valves of different patterns, some with the radial bars below the recess contracted, some with the exit pipe contracted, some with the space between the valve and lip contracted, and others with that space enlarged. If the proper proportions were observed, and ordinary mechanical skill was used in its construction the valve worked.

In the defendants' valve the exit of the steam is *never* free, unrestricted. The moment it should become free, the aid of the recoil action of the steam would be lost, and the valve would only be assisted by the impinging force of the steam. So in the Naylor valve the exit is never large enough to serve as a free exit to the steam.

See ante, p. 7, as to action of valve.

If the exit pipe is too large, of course there will be no retention of the steam sufficient to obtain a recoil action, as in Exhibit G. If the space between the lip of the valve and the casing is too large, instead of a portion of the steam being directed downwards, all of it will go up, past the valve at first, and afterwards all of it will go downwards.

Hibbard, R., p. 147

If the exit below is closed, unless the space between the valve lip and casing is greatly enlarged, the valve will be forced above the casing, and practically destroyed.

Waters R., p. 176

Competent workmen made valves under Naylor's patent that worked. The testimony of defendants' witnesses therefore, that valves made by them strictly according to the drawing and without judgment would not work, should be rejected.

The operation of the defendants valve and Naylor's, is precisely the same excepting perhaps in degree. Both lift the valves higher so as to give a greater area for the escape of the steam; both accomplish the result by confining the steam within an annular chamber or recess, and making use of its expansive power; by utilizing the impinging force of the steam against the down turned lip; by throwing a jet of steam upwards around the valve so as to remove the air pressure from the top of the valve.

In closing, we may be allowed to quote the language of Judge Woodruff in the case of Wheeler *v.* The Clipper Mower and Reaper Co., (10 Blatchford, pp. 187, 188.)

"Doubtless, when viewed in the light of subsequent "improvements, it was imperfect, but it was a very "large advance upon machines for mowing theretofore "attempted. It is one of the embarrassments to "which early inventors are constantly subjected, that "other persons, availing themselves of the substance "of the invention, make improvements thereon, which

" measurably hide the merits of the original; and, if
" the right of a patentee to protection were to be tested
" by the question, whether, in the present state of the
" arts, his invention (without improvement) would be
" deemed of any value, or be salable for use, very
" many authors of most important inventions would be
" turned out of court."

Francis Lucky
Thomas Clarke

SUPREME COURT OF THE UNITED STATES,

OCTOBER TERM, 1877.

EDWARD W. ASHCROFT,

Appellant,

vs.

THE BOSTON AND LOWELL RAILROAD CORPORATION,

Appellee.

APPEAL FROM THE CIRCUIT COURT OF THE UNITED STATES
FOR THE DISTRICT OF MASSACHUSETTS.

BRIEF FOR THE DEFENDANT.

Supreme Court of the United States.

OCTOBER TERM, A. D. 1877.

No. 266.

EDWARD H. ASHCROFT, *Appellant*,

v.

THE BOSTON AND LOWELL RAILROAD COMPANY, *Appellee*.

BRIEF FOR THE BOSTON AND LOWELL RAILROAD COMPANY.

STATEMENT OF THE CASE.

This is an appeal by the present plaintiff, who is the plaintiff in the original action, a bill in equity, from the judgment of the Circuit Court for the District of Massachusetts, dismissing the plaintiff's bill; and the bill of complaint was filed Dec. 14, A. D. 1869, and the judgment of the Circuit Court was rendered at the May Term, A. D. 1874, of that Court.

The bill charges that one Wm. Naylor, of Middlesex County, England, was the inventor of a new and useful improvement in steam valves; that he obtained Letters Patent for the same in the United States on the sixteenth day of October, A. D. 1866, antedated Jan. 24, A. D. 1864; that the said Naylor, Sept. 8, A. D. 1869, assigned his patent to the plaintiff; that the patent was surrendered and reissued Nov. 9, A. D. 1869; that the defendant has infringed upon said patent; the bill then asks for an injunction to restrain the defendant from further infringement and for an account.

The answer denies that Naylor was the first-inventor of the improvements in the steam valves as alleged; alleges that the improvement had been known and used before Naylor's alleged invention, and that they had been at the time of said Naylor's application for a patent in public use or on sale for more than two years with his consent and allowance.

The answer also denies that the reissued patent was for the same invention described in the original patent, and alleges that the surrender and reissue were fraudulent and void.

The answer admits the using of steam valves, but denies that the said valves were patented to the plaintiff, or that the defendant, by such use, in any way infringes or encroaches upon the rights of the plaintiff; it alleges that the improvements, specified as Naylor's inventions in his reissued patents, were known to and used by several persons, whose names are given long before the invention by Naylor.

The answer also alleges that the steam valves used by the defendant, and claimed to be an infringement of the Naylor patent, were described and contained in two English patents, set forth, and two American patents, set forth, in one of which, Richardson's, the invention was prior to the invention and patent of Naylor.

The answer also alleges that Naylor was an alien at the time this patent was granted, and that he neglected, for eighteen months from the date of the patent, to put and continue on sale to the public, on reasonable terms, the invention for which this patent issued. To this answer there is a general replication, and testimony was taken by both parties.

By agreement filed in the case (Report, page 5), the evidence taken in the case of Richardson *v.* Ashcroft, pending in the same Court, was to be used by either party in this case.

The bill was dismissed upon the ground that there had been no infringement. Report, pages 188–192.

THE CLAIMS OF THE DEFENDANT.

The defendant's claims are those set forth in its answer, as given above, and its contention is that all those claims are established by the proofs.

Brief for the Boston & Lowell Railroad Company.

The testimony in the suit of Richardson *v.* Ashcroft is by stipulation admitted in this case, p. 245 of the record.

The common safety-valve, however valuable an invention, failed to secure safety under all circumstances.

Springs, for compressing safety-valves, came largely into use. They were not so liable to get out of order; jolting did not affect their operation; they were more compact, and obviously better every way, especially for locomotive boilers.

The use of springs, on common safety-valves, was not unattended with evil results. As the spring was compressed by the lifting of the valve, its power to resist was largely increased; and, if steam was generated rapidly, the pressure in the boiler would continue to increase, while steam was escaping at the valve.

The power of the steam under the valve, after it began to blow, did not increase in the same ratio as the power of the spring above it.

In this contest between the steam and the spring in the common safety-valve, the spring was the victor.

On p. 38, Ans. 8, Mr. Cephas Manning testifies that "after shutting off immediately, on the road, he has known a correct steam-gauge to go up twenty-five pounds with levers and springs in order."

The danger of relying upon common safety-valves, especially on the boilers of locomotives, constantly liable to be flagged up on the road, or otherwise compelled to stop sud-

denly while generating steam at their utmost capacity, called for something more efficient.

The desideratum was a safety-valve that would certainly prevent the increase of pressure in the boiler beyond a given point, and be at the same time suitable and convenient to be carried on locomotives.

This was attempted at different times, and by different persons, but never with success, until the invention, by George W. Richardson, of the valve used by these defendants; and for which they are sued as infringers in this case.

Immediately upon the Richardson valve being brought to the attention of railroad men, it went into general use all over the country; and there is no pretence that any valve such as is described in the plaintiff's patent ever was in use anywhere.

The first record of an attempt to remedy this defect in the common safety-valve is contained in the American patent of Henry Waterman, dated Nov. 15, 1853, reissued July 9, 1867, Record, pp. 51 and 54.

The following are all the patents referred to in the record with the pages of the record, and dates of the patent: —

p. 51, Henry Waterman, Nov. 15, 1853, American.
p. 54, " " reissued July 9, 1867.
p. 44, Thomas Green, Nov. 9, 1859, English.
p. 41, Charles Beyer, Oct. 23, 1863, English.
p. 47, William Naylor, Jan. 21, 1864, English.
p. 57, George W. Richardson, Sept. 25, 1866, American.
p. 60, Wm. Naylor's American patent, Oct. 16, 1866.
p. 6, " " reissue to E. H. Ashcroft, Nov. 9, 1869.

All of these patents have an overhanging lip projecting outside of the valve seat. The only one in which the over-

hanging lip is of no practical utility to assist in raising the valve is the Naylor valve, and it is the only one in which the overhanging lip is disclaimed as a part of the patentee's invention.

They all contain descriptions of the means adopted by the inventors to give the steam additional power to raise the valve after the valve commences to blow, whereby some additional power may be exerted, by the escaping steam, to assist in opening the valve. A description of the devices adopted in each for this purpose is necessary for a full understanding of the case.

1. The Waterman valve. This has an annular chamber outside of the valve seat, in which the steam collects, and again exerts, by its expansive force alone, a new and additional power in raising the valve and relieving the boiler.

Its operation in this respect is obvious upon an inspection of the drawings, but it was never written in the specification until after the issue of the Richardson patent.

The reissue specifications, p. 56, say this valve will not permit an increase of steam in the boiler after the valve has commenced to blow, and will close after reducing the pressure about three pounds.

Mr. Hibbard, p. 25, ans. 27, finds this to be the working of the valve.

Mr. Hervey Waters, in the Richardson *v.* Ashcroft record, explains the working of Waterman's valve, pp. 158, 159 and 160, as due to the expansive force alone of the steam, and also why the Waterman valve was short-lived and therefore of little value. It would wear out too soon.

Mr. Richardson, also, on p. 66, Ans. 26, gives the same account of this valve.

2. The second patent, in the order of time, was Thomas Green's, in 1859.

His valve, like Waterman's, got its increased power by acting on a larger area, consisting of an annular space out-

side of the valve seat. Its power was derived from the expansive force alone of the steam.

This appears from the specifications and drawings.

See also Hibbard, p. 21, Ans. 11.

3. The next is Charles Beyer's English patent of Oct. 23, 1863. He says in his specifications, p. 44: "It is well known that the common or ordinary safety-valve, when loaded to counterbalance given pressure of steam, does not lift or blow off freely until the pressure has increased to a considerable extent above the pressure fixed upon, consequently the boiler is but slowly relieved of the excess of pressure owing to the small area of the opening of the valve.

"The object of this invention is wholly or partially to remove this defect by causing the safety-valve, when the pressure has become sufficient to overcome the weight upon it, to lift much higher than the common safety-valve, and thus give a larger opening for the escape of the steam or other fluid.

"This invention consists in forming a flange round the valve, commencing at the outer edge of the valve facing, which flange is undercut and concave in shape, and the concave side is towards the seating of the valve, which has also a flange upon it, commencing at the outer edge of the valve seating, but the upper surface of the flange is convex, and corresponds nearly to the concave surface of the flange upon the valve. There is a slight space between the concave and convex surfaces of the two flanges, and its force thus acts upon a larger area, and reacts upon the concave surface of the valve and causes it to open to a greater extent than the ordinary safety-valve."

It may be well here to observe that the patentee, Beyer, refers to the fact that even with weighted valves (*i. e.* without springs), and therefore the resistance to the rise of the valve remaining constant and uniform, "the common safety-

valve does not lift or blow off the pressure freely until the pressure has increased to a considerable extent above the pressure fixed upon." This is doubtless due to the fact that after the steam has begun to escape from the common safety-valve, the pressure under the valve could not increase, the mere act of the steam in escaping preventing such increase.

Naylor knew what had been done by Green and Beyer, and therefore, in the 16th, 17th and 18th lines from the top of p. 49, he says: "But I wish it to be understood that I lay no claim to such recoil action, nor to the extension of the valve laterally beyond its seat."

He says, at the bottom of p. 48, *et seq.*, that his invention consists, when using a spring for resisting the valve from opening, of the employment of a certain kind of levers.

And on the bottom of p. 49, he says, "When the apparatus is properly constructed, the resistance against the lifting of the valve will be uniform, or nearly so, in whatever position the valve may be." His invention consisted in substituting a certain combination of springs and levers, which should take the place of weights, be equally uniform, and perhaps remedying other defects.

If Naylor had sought to do, and had done, by the valve alone, what Richardson has done, he would have accomplished too much. He would have overcome the amount of the increasing resistance of the spring, both by the structure of his valve and by his bent lever, and his valve would have been worthless. If the construction of the valve was sufficient, he would not need his bent lever; he needed and patented his bent lever, because the valve did not without it accomplish the purpose. He used and designed the curved lip for no other purpose than to turn down the steam, and where he didn't use the exit pipe B, he had no curved lip.

We shall presently see that none of these valves, however ingenious in some respects, were of any practical value; that none of them were ever in use in this country, and that

as soon as Richardson's valve became known, its superior efficacy brought it promptly and immediately into general use. It did what no safety-valve had ever before done. It made it impossible for the pressure to increase in a boiler after the valve began to blow, and at the same time was durable. The Waterman valve properly constructed, and with a spring directly above it, and holding it down, would relieve the boiler, but would not last long enough to be a reliable and economical valve.

The Richardson valve proved to be the desideratum in safety-valves. It promptly relieved the boiler, and was economical, efficient, and durable.

It is compact, overcoming the increased power of the spring when acting directly upon the valve, and without the intervention of any other mechanical devices.

This contest between the Naylor and Richardson valves does not have, on the part of Ashcroft, even the merit of the honest belief of an inventor who thinks he has discovered that he builded "better than he knew."

It is the wicked attempt of a pirate, actuated by malicious motives, to deprive a poor and honest inventor of the fruits of his industry and ingenuity.

This is proved by the testimony of Mr. Leach, p. 40 of the record, and the letters on pages 92, 93, and 94 of the record. The letter of Sweetser, on p. 93 came from the plaintiff.

There is no attempt to disguise his purpose. Mr. Ashcroft admits that he went deliberately to work to find something that could be useful in fighting Mr. Richardson and his patent, and that he for that purpose went to Europe to get an assignment of the Naylor patent.

Having obtained his patent, the plaintiff's first effort is to endeavor to claim that the outer annular passage, which is ordinarily used on the Richardson valve, corresponds with what he calls the annular chamber of the Naylor valve.

This was his *prima facie* case.

Increase S. Hill, Ans. 5, p. 10, says that in both the annular chamber is that into which the steam is *deflected* by the curved lip of the valve. See also his answers to Ans. 17 and 18.

That such was the understanding of Mr. Hill is apparent when, though mistaken in the fact, he states, in answer to Int. 46, p. 14, that the Naylor valve "is open at the top, but not at the bottom."

This view of the case was met by the testimony of Manning, p. 39, and Daniels, p. 90, that such a device had always been used upon all valves to turn up the steam to get rid of it after it had left the valve.

PLAINTIFF'S PATENT.

The plaintiff's reissue patent, Exhibit No. 1, admitting for the present its validity for all its claims, is for the annular recess, or chamber D, substantially as described, and for valve C and recess D as set forth and for the purpose set forth. These relate to the portion of the patent relied upon in this case.

The chamber is not described at all in words. Its size, shape and proportions can only be got at by reference to the drawings.

The specification refers to the drawing. "Figs. 1 and 2, of the annexed sheet of drawings represent, respectively, a vertical section and front elevation of a safety-valve, constructed according to my patent."

"A is the main thoroughfare, leading directly from the boiler."

"B is a lateral branch or escape passage for a portion of the steam, after it has passed the valve C."

An inspection of the drawings leaves no doubt of an annular passage around the valve, with full openings into passage B, and by said passage into the open air.

The drawings of the English patent have some drawings not in the American, but neither leaves any doubt of an unobstructed passage for the steam.

Wm. C. Hibbard, p. 21, Ans. 8.

The defendant's valve has no branch pipe to carry off the steam, or any part of it. It is in no respect like the plaintiff's device, and the plaintiff cannot recover, unless his patent is for any and every overhanging lip and chamber outside of the valve seat. This, as we have already seen, is not the case.

THE BEYER VALVE.

The Beyer valve anticipates Naylor's in every particular.

Record, 41.
W. C. Hibbard, p. 21, Ans. 9 and 10.
Also pp. 145 to 148 inclusive.
Hill, Ans. 12, 13, 14, 15, 41, 42, 43, 44, pp. 11, 12, 13, 14.

Compare experiments with the Naylor valve, described by Hervey Waters in the record of Richardson *v.* Ashcroft, pp. 154, 155, Ans. 7 and 8, with the experiments with the Beyer valve, in witness's answer to Int. 12, on pages 157 and 158.

These experiments prove that the mode of operation in the Naylor and Beyer valves is substantially alike, independent of the levers. They prove that in both valves the steam has no static or elastic pressure outside of the valve seat, and that whatever increased power it has upon the extended lip of the valve is due to the impact or impingement only of the steam.

As far as the claim in the Beyer patent is concerned, it is broad enough to cover all the plaintiff claims. In the seventh to the eleventh lines, inclusive, from the top of page 43, it reads, "When the steam begins to escape from between the

surfaces of the valve, it gets between the concave and convex surfaces of the two flanges, and its force thus acts upon a large area, and reacts upon the concave surface of the valve, and causes it to open to a greater extent than the ordinary safety-valve."

In view of this patent, Naylor could do nothing else than say, as in the sixteenth and seventeenth lines of page 49, "But I wish it to be understood that I lay no claim to such recoil action, nor to the extension of the valve laterally beyond its seat"; and confine his patent to springs, to take the place of weights

In Beyer's valve, while his extended lip gave him some additional lifting power, that amount, though small when compared with the Richardson valve, was too much when used upon weights remaining always the same. Beyer found it easy to open the valve, but the enigma was also to close it; and the bulk of his specification is taken up in describing means for that purpose.

Naylor's valve contemplated weights which gave an uniform pressure, or peculiar springs which gave an uniform pressure, and if he had any considerable increase in the static or expansive power of the steam under the lip of the valve beyond the power which first raised it, it could not close until the boiler was nearly emptied. The increased power of the steam, due to the enlarged area of the valve, being largely in excess of the power of the spring, and the power of the spring remaining uniform at any lift of the valve, the valve would not only open to its utmost capacity, but remain open while there was any steam in the boiler.

For this reason Naylor could not afford to use any increase of power, except only such as resulted from the slight amount coming from the impact upon the lip, for the reasons before given.

This is proved by experiments made with the Naylor valve with the bottom closed, when the valve was too much

for even the Richardson spring, that is, a spring directly over the valve.

See Hibbard, pp. 35, 36, Ans. 29, 30, 31, 32.

Exhibit G is a valve exactly like the drawings in the Naylor and Ashcroft patents, with the exception that it is of exactly twice the size of the valve shown in the drawings.

See also deposition of Waters in record of Richardson *v.* Ashcroft, pp. 167, 168, Ans. 50, 51, 52, 53. See Waters's further explanation of this in Ans. 105, p. 175, 176, 177.

The proposition may be stated thus: —

A safety-valve is placed in a cylinder like the Naylor valve casing, except that the bottom is closed so as to form, when the valve opens, a stricture between the outer edge of the lip of the valve and the valve casing. Any such opening between the outer lip of the valve and valve casing, which is small enough to so obstruct the passage of the steam as to cause the static or expansive power of the steam to exert itself, would be a stricture. What would be the operation of such a valve? Let us test it with a two-inch valve, upon a locomotive engine equal to four square inches, set to blow at 100 lbs. pressure. The power of the spring is 400 lbs. The engine is at work, and steam is being generated very rapidly, the gauge indicating nearly 100 lbs. when it "flagged up." The pressure immediately increases in the boiler above 100 lbs. to the inch, the valve lifts, the steam is confined between the lip and the valve casing, and thus a static pressure is exerted upon the entire area of the valve within the outer lip, instead of within the ground joint. Now, the area of the whole valve in all cases is more than twice the area within the ground joint. There is therefore a power of upwards of 800 lbs., instead of 400, exerted by

the steam upon the valve; and this power is constant, because the diameter of the cylinder is uniform.

This illustrates the fact that the capacity of an uniform stricture is the capacity of the valve, and it is *impossible* that such a valve should relieve the boiler. It would be an ingenious contrivance adapted to prevent the accomplishment of the purpose of a safety-valve, and placing the common safety-valve in such a cylindrical chamber would be a positive injury to that valve.

The form of the stricture is of no consequence, nor its position with reference to the lip of the valve, so long as it is a stricture, uniform in size at all lifts of the valve, and gives to the valve the static or expansive power of the steam under the enlarged area.

This is abundantly proved by the testimony of Mr. Hibbard and Mr. Waters, last above alluded to.

While these considerations show the impossibility of making a Richardson valve out of a Naylor valve, they are adduced at this time to show that Naylor's invention did not contemplate any stricture or the use of any static or expansive power of the steam.

If such a valve rises at 100 lbs. to the square inch, that is, with a pressure of 400 lbs., the power is immediately increased to 800 lbs., because of the larger area. *And the spring of the Naylor valve*, by reason of the bent levers remaining uniform, the valve couldn't close until the steam is reduced to less than 50 lbs. to the inch, which would reduce the pressure of the steam upon the whole valve to less than 400 lbs., and less than 200 lbs. inside of the ground joint.

This result, startling and certain as it is, falls short of the reality.

Blanchard, in Ans. 214, p. 127, makes, in Exhibit G, the Naylor valve, the valve two and one quarter inches in diameter, its area being three and eighty-seven one hundredths

inches, and inside the valve casing four and one eighth inches, its area being eleven and eighty-one one hundredths inches; and as the area inside of the outer lip is but little less than that, it is apparent that the increase of pressure of the steam upon the valve, after it had lifted from its seat, would be little less than 1,100 lbs., which would reduce the steam in the boiler from 100 lbs. to about 30 lbs.

The utter impossibility of relieving the boiler by any means other than by enlarging the opening of the valve is shown by the figures on page 141, 142. The velocity of steam under one pound pressure is 482 feet per second. But if, after a pressure has been applied of 100 lbs., a pressure of ten additional pounds is applied, the velocity is increased only fifteen feet, or one and a half feet to a pound's pressure; and an additional pound, after a pressure of 120 pounds has been applied, will increase the velocity only six tenths of a foot per second.

It follows, therefore, that in all cases where there is a chamber, outside the valve, which receives the steam as it issues from the ground joint, which chamber has an outlet so restricted as to form a stricture, such as has been testified about, and so confines the steam as by its static or elastic pressure to exert an additional force to open the valve still farther, against the increasing pressure of the spring; and said stricture is of uniform size at any lift of the valve, — a valve so constructed cannot relieve the boiler against an increasing volume of steam, such as takes place when a locomotive is flagged up on the road.

If such a valve should lift at a 100 lbs. pressure, while steam generated is not taken away by being used, the additional velocity of discharge would not be in proportion to the additional increase. It would, as is seen, be only one and a half feet to the pound, an insignificant increase.

In other words, while the increase of steam is unlimited, the increase of the discharge is limited.

In other words, it is not a safety-valve.

If testimony were wanted to support a conclusion so obvious, it is found in the testimony of Mr. Waters, in the Richardson *v.* Ashcroft record, on the top of p. 12, where he describes how the Naylor valve continued to rise, and would not relieve the boiler, with an increase pressure under the lip, due to the impingement of the steam, of two pounds to the inch.

See also testimony of Hibbard, p. 23, Ans. 17–19; and of Richardson.

The valve of the defendants is substantially different from the valve described in the plaintiff's patent, in its construction and mode of operation.

A mere inspection shows the difference in construction.

The difference in the mode of operation is clearly set forth in the following testimony: —

Hibbard, Ans. 5, 6, 7, 8, 20, 23, pp. 19 to 21, and 23 and 24.

G. W. Richardson, Ans. 17, 18, 19, 22, pp. 65, 66.

Answers to Cross-Interrogatories 48, 51, 76, 114, 117, 150, 154, 155, 156, pp. 72, 73, 75–79, 82, 83.

Waters' Testimony in Richardson *v.* Ashcroft, answers to Interrogatories 6, 7, 8, 9, 10 11, 12, 13, pp. 155-60.

Cross-Interrogatories 24, 27, 32, 36, 91, 102, 105, 113, 114, 122, 124, 127, 128, 143, 151, 156, pp. 162–5, 173–175–7, 178–84, 185–87.

It may be taken as established that the common safety-valve is defective, because of its lack of power to raise the valve sufficiently to relieve the boiler, and that a valve with a uniform stricture is still worse, as having a dangerous limit to its capacity.

We have also shown that the Naylor valve acts like the common safety-valve; it will not relieve the boiler. The steam continues to rise in spite of it, and has to be diminished by independent means to permit it to close.

Hibbard, Ans. 31, p. 36.

It will be noticed that Mr. Waters, by actual experiment, finds the impact of steam upon the lip of the valve to be of greater force *when combined with or used in a recess*, than Mr. Hibbard had done. Mr. Hibbard, however, testifies to certain experiments, which also prove the value of such impact when combined with a suitable recess. Hibbard's re-examination, pp. 145 to 148.

The Richardson valve, used by the defendant, has a variable stricture at the outer side of the recess. This variableness of the stricture, enlarging as the valve rises, is one of the essential features of the Richardson valve. It is not only essential to let the steam into the recess, but to let it out. The recess opens the valve to let more steam into the recess, and also to let out all that is let in. This is done by one operation where the valve is properly constructed.

Mr. Waters, Ans. 151, p. 186, says: "I believe it is true, that there is always two openings of a valve, the first and second openings, when constructed according to the patent of Richardson. But when the valve is at its best, I am unable to detect any space of time between the first and second openings, because the second follows the first so quickly as to run them together, so far as my ear is concerned."

In answer to Cross-Interrogatory 156, p. 187, Mr. Waters says there are two important features entering into the Richardson valve.

"1st. A peculiar stricture by means of which the steam escaping from the valve is made to act by its expansive force

upon an additional area outside of the valve proper (but practically integral therewith), to assist in raising the valve; this stricture being so constructed and combined with the valve as to be enlarged when the valve is considerably lifted from its seat.

"2d. The peculiar construction and arrangement of the additional area or lip in relation to the valve proper, so that the impinging force of the jet of steam escaping through the valve proper is made of direct utility in lifting the valve.

"Now, my understanding of this matter is, that Richardson was the first to embody these two features in a valve working together in the manner he has described in his patent; and inasmuch as the valve inquired of would have both these features working together somewhat in the manner described in his patent, I think it would contain the principle and mode of operation invented by Richardson."

Again he says: —

"*Cross-Int.* 142 (p. 185). Is it not true that the opening at what has been called the stricture, will operate more or less effectually as a stricture as you understand and apply that term, depending upon the amount or degree of the pressure in the boiler while the valve is blowing off?

"*Ans.* Yes, it is; with a given opening at the ground joint.

"*Cross-Int.* 143 (p. 185). Please explain that answer.

"*Ans.* It is obvious that the greater the pressure within the boiler, the greater will be the amount of steam discharged through the ground joint, if the opening at the ground joint remain of a given size. It is also obvious that, with a given size stricture in connection with the close chamber, such as in the Richardson valve, the more steam there is to be driven through it, the greater will be the expansive force of the steam within the chamber, and therefore the stronger will this expansive force act upon the extended area of the lip of the valve to overcome the tension of the spring."

Again he says, Ans. 122, p. 181: "The difference resolves itself into this: In the Richardson valve the stricture varies in size as the quantity of steam blown off varies."

In answer to 113, p. 179, he says: "The point of difference is this: In the Richardson contrivance the escaping steam is always restricted, but the restriction is variable."

In these remarks he is contrasting the Richardson valve with a hypothetical valve with the bottom closed, so as to make a close chamber. The plaintiff's valve has no stricture at all.

In answer to Cross-Int. 72, p. 170, Mr. Waters says he has a half-inch Richardson valve which he finds more efficient than a two-inch common valve which he took off, and than a Naylor valve made of the size of the Naylor drawings.

The testimony is ample that the Richardson valve will effectually prevent any increase of steam beyond its point of blowing; and in all the others there is an increased pressure of the steam, and no certain relief of the boiler.

The testimony of Increase S. Hill, the complainant's first witness, corroborates the defendant's testimony as to the working of the Beyer valve.

Cross-Interrogatories 4, 5, 6, 13, 14, 15, pp. 11, 12.

The great mistake of Mr. Hill was that he did not understand the Naylor valve. He had been led to believe that the chamber D was closed at the bottom.

Cross-Interrogatory 46, p. 14.

He once experimented with a Naylor valve produced by Ashcroft, "which opened and closed without a sudden and loud report"; showing its mode of operation to be different from the Richardson valve.

The conditions of firing at these experiments are not given, and a comparison of the valves in other respects is therefore

out of the question. That Naylor valve is not produced, and none are produced by the plaintiff that at all resemble the valve of his patent.

The plaintiff has not produced a valve made according to the drawings. He did have one. This is drawn from Mr. Hill in his cross examination, — Cross-Ints. 63 to 82, and 86, pp. 15 to 17.

He says, in answer to Cross-Int. 97, that Mr. Ashcroft — and to 98, p. 17 — that he never saw any other Naylor valve; and to 66, 67, and 68, p. 15, he answers that it went back into Mr. Ashcroft's possession.

In answer to Cross-Int. 81, p. 16, he says of the Naylor valve, "While it relieves the boiler equally as well, it opens and closes without making a sudden and loud report."

What Mr. Hill means by equally well, does not appear; whether the pressure increased, and how much before relief came, and how long it took to relieve the boiler, does not appear. There is one distinction that does appear. It does appear that it opened and closed without the sudden and loud report that is found in the Richardson valve.

This is the great difference between a sudden and complete relief and a gradual one; between a sure relief and one that cannot contend against the increased power of the spring.

The Richardson valve opens wide instantly — hence the loud report. It relieves the boiler instantly — hence the sudden closing.

The Naylor valve, when constructed according to the patent, opens and closes like the common safety-valve, gradually.

This testimony of the plaintiff's witness corroborates the testimony of Mr. Richardson, Mr. Hibbard and Waters, above alluded to.

This valve, which Mr. Ashcroft made and furnished to Mr. Hill to experiment with, he does not produce.

This Naylor valve which Hill testifies about probably comes

to the surface again in Mr. Blanchard's testimony on pp. 107, 108, answers to Cross-Ints. 54, 55, 56, 57, 58–60, 70.

Whatever valve this was, it is not produced. It did not work as the Richardson valve works.

The valves which the plaintiff, Ashcroft, does produce, are unlike anything in any patent. They are wholly inadmissible for any purpose. They are produced on the theory that a patentee can, when the trial comes, discard his drawings, and, after experiments, make an entirely new instrument to take the place of the one described in his patent.

No things could be more dissimilar than the valves described in the Naylor and Ashcroft patents, and the Exhibits 3 and 4, and all the exhibits relied on by the plaintiff, Ashcroft. In answer to Cross-Int. 200, p. 125, Mr. Blanchard admits that while the nozzles B are alike, the areas of the openings are six times as large as in the patents. In Ans. 201, p. 125, he says 3 and 4 are not like the drawings. And in Ans. 203, p. 125, he admits that in the patents, Exhibits 1 and 3, exit pipe B is three fourths of an inch and one sixteenth greater than inside the ground joint, and in Exhibits 3 and 4, exit pipe B is half an inch less than the diameter inside the ground joint. Ans. to Ints. 207, 208, and 209, p. 126, describe other differences. Even in the details of construction, these pretended valves are entirely different from the Naylor patent.

See "Hibbard Drawing" and "Cambridge Drawing."

This witness, in answers from 216 to 224, pp. 127, 128 inclusive, justifies the use of a diaphragm not represented in the drawings, nor mentioned in the specification, because — Ans. 223, p. 127 — there is no sectional drawing through the partitions or radial bars, or at some other point where a view of such bars or partitions could be had without being obstructed. And in answers 225, 226, and 227, p. 128, he admits there is just such a drawing of which he was not previously aware.

The drawings speak for themselves and confound the testimony of this witness.

Mr. Hibbard, Ans. 8, p. 21.
Mr. Waters, Ans. 16, pp. 160, 161.

The law has always required drawings to accompany specifications as a part thereof.

The Statute of 1870, Sect. 53, provides that neither the model nor drawings shall be amended except by each other; "but when there *is neither model nor drawing*, amendments may be made upon proof satisfactory to the commissioner that such new matter or amendment was a part of the original invention." Yet this witness attempts to contradict drawings in order to support a theory of his patron.

The struggle of this witness to make a case is constantly cropping out.

He finally admits that his whole testimony was given while in error as to a fact stated in the drawings.

After having sworn that all the proportions of a Naylor valve may be changed, and that the drawings may be disregarded, on p. 213, in Ans. 237, p. 129, he says: "There is *nothing in the drawings to lead* me to understand that they do represent the sized valves referred to in the question, but in looking at the specification I do find that Figs. 1 and 2 of the *annexed sheet of drawings represent respectively a vertical section and a front elevation of a safety-valve constructed according to* my invention; and I further find it stated that Fig. 4 *represents* a vertical section of a portion of a five-inch safety-valve adapted for large marine or land boilers, constructed according to this invention. Without the information derived from the specification, it *would never have occurred to my mind* that the drawings were intended to show such a variety of valves."

"*Cross-Int.* 238 (pp. 129, 130). What do the words 'half size' in said drawings, opposite Fig. 4, mean, and what do

the words and figures 'one fifth full size,' opposite Fig. 5, mean?

"*Ans.* I have no doubt that they mean what they say, *and that I was in error* in my last answer in saying that there was nothing in said drawings that would indicate the size of the valves there shown."

We have already seen how this witness testifies that drawings and specifications may be disregarded, and the valve and all its proportions changed, and diaphragms inserted, in order to make pressure under the valve, because Naylor says a part of the steam will go up past the valve, though the inventor expressly disclaims any such thing as belonging to his invention; yet, when he comes to deal with the Beyer valve, he won't alter that valve, but insists that Beyer has failed in his object, though much more distinctly stated than by Naylor. Blanchard's Ans. to Int. 281, p. 135.

Again, at 18th line from top of p. 101, this witness — who has been testifying that Richardson's simple contrivance is an infringement of Naylor's cumbersome bent-lever contrivance, discarding the latter as not bearing upon the question — brings in all that is described in the Beyer patent to show that it would be "very cumbersome and expensive," and that the valve couldn't be used without it without considerable loss of steam."

Again, this witness, in answer to Int. 16, p. 103, says he tried an experiment with a Richardson valve with the lip turned off; that it started to rise at 63 lbs. and popped at 65½ — an increase of 2½ lbs.

A recess is taken, and he corrects his statement and says it popped at 70. In answer to Int. 96, pp. 111–12, he states the same experiment as starting at 60 and popping at 67.

For the variations in the stricture of the Richardson valve at its various lifts, reference is made to Exhibit T, J. G. Stetson, Jr., and G. W. Richardson's answers from 172 to 182, inclusive, pp. 84, 85.

The plaintiff's testimony relating to experiments with the Richardson valve must be taken with the fact (G. W. Richardson, Ans. 173, p. 84) that "one thousandth part of an inch in the width of this opening makes a great difference in the opening and closing of the valve."

Where Blanchard had the lip turned off the valve seat there probably was a sufficient difference in the opening to account for all the difference he testifies to.

This is the more apparent because Mr. Hibbard, by raising the lip upon the same valve three sixteenths of an inch, makes no difference in the operation of the valve. It closes at the same pressure in each experiment, and opens at one pound only difference, and this must be due to the friction of the parts, as the difference in the *opening* could not be affected by the lip outside the valve. However viewed, the difference is immaterial.

1. The plaintiff's patent has no recess or annular chamber which can accumulate steam and give additional pressure. It is only an annular passage to carry away the steam.

2. The steam has no force upon the curved lip except only a slight impinging force, and in this respect is like Beyer's.

3. All the diaphragm valves are out of the case as not like anything in any patent, and are not entitled to be considered, and if considered are radically and entirely different in construction and mode of operation from the Richardson valve.

5. The Richardson valve is substantially and radically different from anything described or appearing in the plaintiff's patent.

6. The thing sought to be covered by the reissue is clearly not within the original invention of Naylor, and the wholesome doctrine enunciated by this Court in Forsyth *v.* Clapp *et al.* is applicable to this case: —

"The Court will look beyond the mere form of words, in

the claim of a reissued patent, into the specifications in both the original and reissued patent; and even if on the face of the reissued patent it does not embrace anything not described or suggested in the original, nevertheless the Court will ascertain whether there is any substantive invention adequate to support a claim ingeniously worded, not so much for the purpose of describing what the patentee really invented, as of grasping within its terms some contrivance not within the knowledge or contemplation of the patentee, and for that reason, not by reason of inadvertence or mistake, not embraced in the claims of the original patent."

REISSUE NOT VALID.

The reissue, if it can be held to embrace anything beyond the bent levers claimed in the original patent, cannot stand.

The Commissioner could not hear parol testimony, and could only reissue for the original invention.

The reissue seeks to cover what was not indicated as the invention of Naylor, but was expressly disclaimed.

Seymour *v.* Osborne, 11 Wallace, 516.

The patent is void, because the inventor neglected, for eighteen months from the date of the first American patent, to put and continue on sale to the public, on reasonable terms, the invention for which the patent issued.

Act of 1836, Chap. 357, Sect. 15.

Increase S. Hill, complainant's witness and United States local inspector of boilers and engines of steam vessels, p. 17, Ans. 98, says he never saw a Naylor valve except the one with which he experimented. This was on Sept. 12, 1870. Page 15, Ans. 65.

That no such valve was in the market also appears from the testimony of Leach that Ashcroft had to have the Patent Office searched to find it. Page 40, Ans. 6.

Cephas Manning, Superintendent of the Grant Locomotive

Works at Patterson, N. J., and who had been master mechanic of the Milwaukee and Prairie Du Chien, Marietta and Cincinnati, Louisville, Alton and Chicago, and the New York Central Railroads, had never, except in the Richardson valve, seen anything on valves outside of the valve seat except a collar to turn up the steam, and that was on the common safety-valve. Page 38, Ans. 6 and 7.

John Daniels, until the advent of the Richardson valve, had never seen any other except the common safety-valve. Page 91, Ans. 6.

The whole testimony shows that the Naylor valve was never used, and never in the market. And the plaintiff offers no evidence to meet this testimony.

DATE OF RICHARDSON'S INVENTION.

Mr. Richardson's invention was as early as 1852, antedating all the patents.

G. W. Richardson, Ans. 4 to 14, inclusive, pp. 63–5.
(The cross examination confirms the direct.)
E. C. Richardson, pp. 89, 90.
Reed *v.* Cutler, 1 Story, 590.
Agawam Woollen Co. *v.* Jordan, 7 Wall. 583.
Woodman *v.* Stimpson, 3 Fisher, 98.
Adams *v.* Edwards, 1 " 8.
Colt *v.* Mass. Arms Co., 1 " 108.
Phelps *v.* Brown, 1 " 497.
Vox *v.* Griggs, 1 " 74.
White *v.* Allen, 1 " 445.
Wickersham *v.* Singer, Supreme Court, Dist. of Columbia.
Johnson *v.* Root, 1 Fisher, 351.
Ransom *v.* Mayor, 1 " 252.

J. G. ABBOTT,
BENJ. DEAN,
For Def'ts.

OPENING PO

Supreme Court of the United States.

EDWARD H. ASHCROFT,
Appellant,

vs.

THE BOSTON AND LOWELL RAILROAD COMPANY.

266

Oral argument of Francis Forbes for Appellant.

Printed and submitted by Order of the Court.

If your Honors please, this is a suit in equity, commenced by a bill filed in the Circuit Court, for the District of Massachusetts, for the infringement of letters patent, for an improvement in steam safety-valves, granted to the complainant in this case, as the assignee of the inventor (William Naylor) who was an Englishman. Mr. Naylor had taken out a patent in England in 1863, and applied in this country for a patent in 1866, which was granted. The present suit was brought on the reissue of the latter patent.

The answer was filed February 7, 1870, a replication also, of the same date. Proofs were taken in the ordinary form, extending over a period of some three years, and the case was brought to a final hearing before his Honor Judge Shepley, in the year 1874.

I suppose it will be more convenient to state at this point the defences that are set up in the answer. They were :

First, that the reissue is not for the same invention as the original patent. Second, that William Naylor was not the original and first inventor of the improvements specified in said reissued patent, and that different people named had made the invention before him. Third, that the reissued patent does not cover the valve sued—the defendants' valve. Fourth, that the valve used by the defendants is described and contained in various letters patent of prior date. And, fifth, that Naylor, an alien, had not put his invention on sale within eighteen months after taking out his patent.

I appear for the complainant. The decree was rendered dismissing his bill in 1874, and we allege as error the dismissal of the bill.

You will find in the record, at page 6, the reissued patent under which suit is brought. The original American patent is on page 60, and the original English patent is on page 47. I hand you here the original drawing of each. I do not find that there is any copy among the exhibits. For the convenience of the court, we have had heliotypes made of these different valves which are referred to. They are at the end of my brief. You will find that the first one is marked "Naylor" above it, and that contains the essential part of the invention in controversy.

Now let me go, if the court please,—and I do not think it is a useless waste of time,—into the history of safety valves.

The use of safety valves dates back to the beginning of the use of steam. The common lever safety valve, with which your Honors are perfectly familiar, was invented as far back as 1681. There was no improvement on that, until the beginning of the present century, when steamships and railroads were invented. Of course this common safety valve, of which I have a form before me (see common safety valve used on

argument) was not suitable for locomotive purposes, the difficulty being that the jolting of the engine on the track would cause the lever to be thrown up, and that would release the valve, which would follow the lever (the pressure being underneath the valve), and, therefore, the valve would leak. Now, in order to avoid that, springs were invented, and here is a sample of a spring safety valve (taking up exhibit with spring). Springs were also attached at the end of this long lever (referring to lever valve) in place of the weight. This arrangement is shown at Fig. 1,986, last drawing at end of brief. As your Honors very well know, when this spring is compressed—I can compress it easily with my hand as it is now—after it is compressed slightly, the pressure required to compress it still further increases very largely; so that you cannot set your spring to rise equally through all the distance of its compression. Now there was the difficulty which had to be overcome. One man overcame that in this way: he attached at the end of this long lever a weight, and then he put below it a dash-pot so that no matter how much the boiler was jolted the valve would always remain unaffected—or in its seat—so as not to leak or let out steam. Naylor, the man who made this invention in controversy, arranged this spring as you will see on the drawing, of the patent which I hand up, in a peculiar way, so that the fulcrum was changed at the different points in the lift of the valve, and the pressure of the spring was kept as nearly uniform as possible. This was claimed in Naylor's original English patent; we will have to speak about that hereafter, so if your Honors will pardon me, I will pass it for the present.

The next invention was to extend out the lip of the valve beyond its flat seat so as to get a larger area for the steam to act upon. If your Honors will look at the drawings which you have before you, one marked Waterman at the end of my brief, and the other marked Green, you will see the advance upon this. Now this Waterman valve has an over-hanging lip, and has a small chamber in it which is shown in the draw-

ing issued to Waterman which I handed up a little while ago. *There is nothing said in the patent with reference to this chamber or over-hanging lip. There is simply a drawing of it.* That was in 1853. In 1859 this man Green, who was an Englishman—Waterman was an American—patented a valve which is shown in the drawing which I hold in my hand. That patent also contains a lip, which is extended out horizontally, and against which the steam would impinge and assist to throw up the valve. That was very slightly described in this English patent. The next two valves came very close together in 1863. One is the Beyer valve, and the other is the valve in controversy.

Now, I do not know that I can do better, our time being so limited, than to show your Honors these valves.

(Mr. Forbes here exhibited the Beyer and Naylor valves.)

This valve, "Exhibit Hibbard Naylor model," was made by the defendant, and the other was made by us. The Exhibit Hibbard Naylor valve is not correct; yet it shows the shape of the valve as shown in the drawing. *Our invention consists in turning down the lip so that the steam in issuing from the pipe connected with the boiler will impinge against it. The steam is turned down by the lip into the hollow space, or chamber, or recess, around the pipe, and is confined within that chamber sufficiently to cause it to act expansively, or recoil against the overhanging lip of the valve, and, in that way, lift the valve higher than it would be lifted by the pressure of the steam under the valve alone.* A sheet of steam is also thrown up around the lip of the valve, and cuts off part of the atmospheric presure on the valve. Now, the whole question, I might say here just as well as afterwards, is, whether the steam acts expansively in that chamber or not. That is virtually the whole question in the case. Now, the Beyer valve has the same overhanging downward curved lip as the Naylor (exhibiting the Beyer valve). Q. Where is the chamber in the Beyer valve? If there is any chamber

in this valve it is in that narrow space between the lip and the extended convex seat.

Mr. JUSTICE CLIFFORD: Which is your model?

Mr. FORBES: We have several models here which do not look anything at all like the drawing, and, therefore, I will have to explain afterwards why they were made in this way.

Mr. JUSTICE CLIFFORD: You have no model?

Mr. FORBES: There was no model of this invention in the Patent Office at all; the only model which was filed was this large brass one, which does not show the invention; the only way in which the invention was shown was in the drawing.

Mr. JUSTICE CLIFFORD: I see that there are five claims in the patent; do you claim that they are all infringed?

Mr. FORBES: We do not claim that all the five claims set forth are infringed; the first is a claim for the spring—that we do not claim they are infringing; the second, third and fourth claims are infringed.

I read from page 9 of the present record before your Honors:

The first claim is for the combination of the spring and valve with which we have nothing to do in this case; the second claim is for the safety valve C, with its overhanging, downward curved lip or periphery and annular recess D, substantially as herein shown and described and for the purpose set forth. The third claim is for the annular recess D surrounding the valve seat substantially as herein shown and described, and for the purposes set forth; and the fourth claim is the combination of the valve C and the annular recess D, as herein set forth, etc.

(Mr. FORBES here exhibiting to the court the valve which the defendant used, Exhibit 2). This is the defendant's valve, and this (exhibiting another) is a like valve, cut open in order to show the interior; this hollow space under the curved lip, is a chamber in which the steam is collected.

Mr. JUSTICE BRADLEY: The steam in that hollow

space acts as a cushion when the valve goes back to its seat.

Mr. FORBES: No, sir; the operation is this, steam issues from this pipe which is attached to the boiler, and raises the valves a little from its seat; the steam escapes into that annular space around the valve, and is slightly detained there before issuing into the air so that it expands, If there is a hundred pounds pressure in the boiler, there is perhaps twenty pounds pressure in this annular chamber. Your Honors will see that this overhanging lip being larger in diameter than the valve proper, there is a large additional space on which the steam acts, and therefore the valve is lifted much higher. In the common safety valve (Exhibit T), there is nothing against which the steam can impinge or exert its expansive force after it leaves the valve seat.

Now we have the valve before us and the claims. In order to understand them, it will be necessary to understand the properties of steam, because, as your Honors see by looking at that valve at your right (Exhibit Hibbard Naylor model), there is a permanent orifice for the escape of the steam. There is no enlargement of that orifice. You will see (showing defendants' valve Exhibit 2), that when this valve rises from its seat, there is an enlargement of the orifice of escape. Perhaps my stating it in this way will save time.

THE CHIEF JUSTICE: Have you got your own valve here that we may look at it with this?

Mr. FORBES: I think for the purpose of this case we might as well call this our valve (pointing to "Hibbard Naylor model"). I am perfectly willing to do it. I was not the counsel below in this case, but a far older gentleman than I am, and for that reason I suppose I have no right to criticize his making up the case. This is our valve (exhibiting another one), and you will see it has a very small exit compared with this. This is like our drawing, as your Honors can very well see; it is put in by the de-

fendant, and we will call it our valve. Now, as I was just saying to your Honors, you see this has an exit for the steam which is always the same. There is no variation in it at all. No matter how high the valve lifts, it does not lift above the casing. You can see very easily that the lip is down below the casing. The steam escapes both at this annular orifice above, and at this round exit here. It has two exits. One above throwing an annular sheet of steam up above the valve, and the other below.

The CHIEF JUSTICE: Is that any part of your claim —the exit?

Mr. FORBES: No, sir; the form of the exit is immaterial. The question is, whether the chamber in which the steam is confined is so constructed that the steam can expand to assist in raising the valve by giving an additional pressure.

The CHIEF JUSTICE: Where have you an additional pressure in your valve?

Mr. FORBES: By experiment, we find that the steam in its escape is retarded and expands in this chamber, and Mr. Naylor specially refers to it in his patent. Now, then, although it may look as if there was a tremendous big exit for the steam, yet the steam is actually retarded in its escape, and therefore exerts an expansive force; that is what I am coming to, and think I will explain satisfactorily to your Honors.

I must say, that when I took up this case—one cause was, I suppose, my own diffidence, succeeding a far older man than myself—I took it up and studied it through, and wondered how it was that the steam could escape from an orifice of fixed size, and escape with sufficient quantity to relieve the boiler. I found that the defendant's valve had a variable opening, which raised and made a larger orifice for the escape of steam, when the valve was raised to its greatest height. I went and read through this record, and I think that your Honors will read through the record without this argument, in the very same blind way, except so far as your experience in these causes would

lead you to a more correct judgment than myself. I went searching through the record, and almost gave up in despair. At last I turned to other books and studied the properties of steam. When I had done that, *I became convinced that we had a good case.* In this case Mr. Hibbard says, at page 28, Answer 19:

"I do not recollect the velocity at which steam escapes into the atmosphere at any given pressure. These velocities *are to be found in the books treating upon that subject, which are my only sources of information.* But the velocity of steam escaping from the stricture would be variable, according to the height to which the valve is raised, and the amount of steam discharged during any unit of time. The velocity of the steam, also, at the ground joint, would be variable under these conditions."

Your Honors could not, without some knowledge of the properties of steam, understand that answer. He says information is to be got from the books. Perhaps I have taken an unwarrantable liberty. I have never had the privilege—although I have always looked up to it as the highest honor of my life—of appearing before your Honors. I have printed at pages 5 and 6 of my brief some extracts from the Report on Safety Valves, which was made in Scotland to the Institution of Engineers and Shipbuilders, on the twenty-seventh of October, 1874. It gives some statements in reference to the properties of steam, which seem to me to be necessary to the understanding of this case. It is said in that report—I have the volume of the Encyclopedia Britannica here, which gives the same information—that up to within twenty or thirty years steam was supposed to flow through an orifice in the same way that water flows. It was discovered at that time that there is a very great difference between the two, that steam is a gas, and has peculiar properties.

This is not the case of a turbine wheel, your Honors, where the water enters in and has the same pressure and density at all times. If this valve is put on a boiler that is set to carry fifty pounds pressure of steam, it will operate perfectly as a safety valve. If it is put on a boiler carrying ninety pounds pressure of steam, it will not operate. The reason is that steam, at these different pressures, has different properties. Your Honors well know that steam is not the vaporous body that we see escaping from locomotives, for instance, when they are blowing off, but it is a transparent body, a transparent gas, with different densities consequent on the application of different amounts of heat and different pressures; and it follows that remark, that the steam or gas at a lower density and a lower pressure will not escape from the same orifice with that of a higher pressure and a higher density. Now, it seems to be ridiculous that steam of a higher density and pressure will escape through a much smaller orifice than that at a lower pressure and lower density. Nevertheless it is so. I will have to call your attention to the theory of molecular action. Your Honors have heard in chemical patent cases, no doubt, those terms very many times. While these molecules act in one way when under great heat, or great pressure, they act in an entirely different way when under less heat and less pressure. Besides, all molecules, in attempting to escape from a confined space, impinge against each other on all sides, and exert a force in every direction. Another peculiarity of steam, which I want to call your Honors' attention to, and which is necessary to the understanding of this case, is, that when one of these gases escapes into another gas, *e. g.* steam at 100 pounds pressure escapes into steam at 50 pounds pressure, it is not retarded in the least. That is a physical fact, affecting this cause. If your Honors will allow me, I will briefly try to show you how it does. The action of this valve (Naylor's) is this: The steam, say at 100 pounds pressure in the boiler, is allowed to escape past the ground-joint, and is turned down by the curved lip

into the chamber around the valve, which, in the first drawing of my brief, is called D. Being released from the boiler pressure, it instantly expands in that place, and, of course, the pressure is reduced. Mr. Richardson says (p. 88 Record) that in his valve, when the pressure was at 90 pounds in the boiler, it was only 20 pounds under this lip—that is, the steam had expanded so as to reduce the pressure to 20 pounds. But the steam in the chamber does not retard the flow of the steam from the boiler. Then, what becomes of the steam in the chamber? That was the question which I asked myself. How does it get out of its exit, B, and up and around the edge of the valve? How is it confined in that space? We have a big hole here, and it would seem to any one—and it did seem to Judge Shepley, in this case—that if the steam raised this valve and rushed into the chamber, D, that it would escape from the exit, B, as from a conduit pipe; and they did make an exhibit which acted precisely in that way, which we shall come to speak of hereafter. That was this Exhibit G. It is made very large here, but it is similar to these two valves which are before the Chief Justice. Now, the action of that valve was this: when the valve head was raised from its seat, the steam, escaping, was turned down into the chamber, none of it escaping above the edge of the valve at all; it all escaped out of this pipe. The experts tried to see whether there was a current of air downward into it, and held little pieces of paper above the valve, which were drawn between the valve lip and this casing, and came out at this tin pipe. In this valve the chamber, D, and Exhibit B, are only a conduit for the steam, and do not confine it in the least. The only beneficial effect produced by the steam, is that produced by its impinging against the extended lip. If that is the true representation of our valve we might as well give up the case. I will say that frankly. There is no use in making any concealment about the matter. Your Honors will find it out upon examination. We claim that in a valve constructed as

directed in complainant's patent there is a confinement of the steam at this point where the tin pipe is attached—that the steam is confined at that place, and if it is confined, then, it will assist in lifting the valve, and when the valve is raised high enough, there being steam of greater pressure and of greater density escaping, it will escape through the same orifice that the first steam could not escape through. That is the key to the whole case, that steam at one pressure and one density will escape through an orifice that steam of a lower pressure and of a lower density will not escape through. *This was proved by the experiment made in the cause. Exhibits* 3, 4, 8, *etc., all with an unchanging opening for the final exit of the steam operated.* It is also stated as a fact in all the scientific books.

The CHIEF JUSTICE: The only pressure which you claim for your valve is that which is obtained from the resistance here? (pointing to Exit B.)

Mr. FORBES: The resistance at all points. There is an opening above, as well as at Exit B.

[Exhibiting a model.]

This is not an exhibit but merely to illustrate the fact I have spoken of. This valve is never lifted above the top of the casing, and you see that there are holes all around the side. That acts as a perfect safety valve. When the valve is raised to its greatest hight, of course the steam in the chamber is of greater density, and there is greater pressure, and it will escape through these holes and will relieve the boiler easily and quickly.

Mr. Justice STRONG: What becomes of it when it escapes?

Mr. FORBES: It is simply directed upwards by this rim. If the valve was used without the rim the same effect would not be produced. I may mention this fact, that this rim outside retards the steam in the inside of the chamber to a certain extent, and the holes can therefore be made larger than if the rim was

omitted. I simply brought this forward as an illustration. It is to show what can be done with regard to the escape of steam through orifices.

Mr. DEAN: As I understand, it was not an exhibit in the court below?

Mr. FORBES: No, sir, not at all.

Now I will come to the case. If I have made this at all clear—I attach so much importance to this branch of the case, I would like to have myself understood, and if I am not understood, I should like to go over it again.

Mr. Justice STRONG: Do I understand you to say that your claim against the defendants rests on the fact of this pressure in that outside space?

Mr. FORBES: Yes, sir, that is the primary fact. It rests upon the fact that he uses the same kind of a chamber that we claim we use. He uses an overhanging downward curved lip, and underneath a chamber in which the steam is confined; he does more than that; he throws up around the valve by that rim you see there an annular sheet of steam which cuts off some of the atmosphere above the valve—one of the witnesses says about two pounds to the square inch—and in that way he accomplishes the same thing that our valve accomplishes. We claim that the mode of operation and the principle of the two valves are exactly the same.

Mr. Justice STRONG: The steam goes up and also goes down?

Mr. FORBES: Yes, sir; and the reason of that was this. I take it that it is necessary in all places where safety valves are used, to have a pipe or conduit to carry away the steam. It was used on shipboard for example. They were used on locomotives. One witness says in this case that they either had a ring to throw up the steam so that it would not interfere with the engine driver, or else they had a pipe to take the steam downward to the ground, or else upward (Record, p. 91). A pipe like that pipe on the valve that I

held up before your Honors—a pipe to turn up the steam to get it out of the way.

Now on shipboard the safety-valve may be placed on the boiler down in the hold, and, of course, there must be some conduit or other outlet for the steam. Generally a pipe runs out to the side of the vessel into the water, or the steam may go off by the smoke-stack, or in other ways. That is the reason we claim that Naylor made his valve in this way. It was handy and convenient, and the customary way at that time, *i. e.*, to have an escape pipe.

Now, if your Honors will bear with me a moment, I will show you a large drawing which shows the old form of safety valve. I will say, before going any further, that this explanation, although it takes up my time, will help your Honors to an understanding of the invention, and, I think, assist the gentlemen on the other side, partly because these exhibits are in their printed brief, and referred to, so I will ask your Honors to allow me my full time. (Refers to drawing Exhibit T.) Here are two safety valves, one at each end of the locomotive, in the old style (exhibiting). The main thing is this rim, which is referred to, which is used to turn up the steam. The rim is shown on the last page of my brief, as Exhibit T.

Mr. DEAN: The rim is turned up to keep the steam from scattering all over, and obstructing the sight of the engineer, &c.?

Mr. FORBES: To proceed with the case; this rim, which is on the defendant's valve, Exhibit 2, is nothing like the rim that has been shown to your Honors. It was stated that that was simply to prevent the steam from scattering as it issued into the air. The valve that is before your Honors is something like the one that I hold in my hand. The rim is close up to the lip of the valve, and it is so close up and hollowed at the bottom that the steam, in coming down, takes a sweep and is turned directly upwards, close to the valve, and in that way cuts off the atmosphere from above the valve, and thereby cuts off two pounds,

as one witness said, per square inch of pressure on the top of the valve. As your Honors know, the pressure of the atmosphere is some $1\frac{7}{10}$ pounds per square inch.

Now the complainant's valve (Naylor's) operates in precisely the same way. You have the steam escaping beyond the ground joint into a chamber; a part issuing from the chamber, escapes upwards, in an annular sheet, around the valve, cutting off part of the pressure of the atmosphere from the top of the valve. We claim that the action of the two valves, although their shape is different, is identical in the two cases. If your Honors please, the counsel for the defendant, when they drew their answer, thought the very same thing; they set up in their answer, that this identical invention, that we have claimed in our reissue, was invented by the man who made the defendant's valve. That is the only valve in question. Now they must have believed so at that time, or else they would not have made such an assertion. Mr. Richardson, when he was put on the stand, with regard to the valves, in describing the action of defendant's valve, used words equally applicable to the Naylor valve. His testimony is at p. 72, Record, Ans., 48. I have printed in my brief the testimony of Hibbard, which I will read:

Question. "If the space, through which it escapes "freely into the surrounding air, is larger in a valve "like Exhibit 2, than the opening or space at the "ground-joint, is there any obstruction to the escape "of the steam in point of fact?"

Hibbard says, in answer: "There certainly is, for "two reasons; first, because steam, being indefinitely "expansible, instantly fills the space into which it "flows, with a lower pressure, corresponding to the "amount of dilation; and second, that the current of "steam, as it issues from the ground-joint, is broken "up in that space, and has to again reform the current, "to flow out of the stricture, offering a resistance to "the escape of the steam, which is measured by the

"amount of pressure *that would be required to force* "*that volume of steam, in its expanded condition, through* "*that orifice.*"

In both these valves, as your Honors can see, there is a short space of time when there is no expansion inside of this chamber; that is, when the steam that is leaking out around the valve would be of such small quantity as to escape by this second exit. During that space of time there is no pressure caused by the expansion of the steam.

Let us take up the defences presented by the pleadings. The first defense is that the reissued patent is not for the same invention described in the original patent. In the original patent granted by the United States, there was no mention in the claims of this part of the invention, that we have been talking about. It is shown in the drawing, which is the same in both patents, and described in the specification. His Honor, Judge Shepley, did not seem to take any notice of this defense. He passed it over, and I supposed—but I have so short a time perhaps it would be as well to leave the defense to my associate, and go on with the other defenses in the case.

The next defense is that William Naylor was not the first and original inventor. It is claimed that a man by the name of Richardson was the inventor. These are the facts. In the year 1852, Richardson conceived the idea of this valve which I now hand up to the court. It is without the rim which turns up the steam. A short time afterwards he got out or made a sectional model of this valve in veneer. He simply cut it out of wood sectionally. Afterward he did not really do anything up to the year 1866, in that year he made a complete valve and tried it—an operative valve, and got a patent. He claims that he can take his invention back to the year 1852, when during all that time he was earning, as he says, $2 a day, and at times $1.75 a day. He owned real estate at different times. He sold his house, and

had $300 clear. He had more than money enough to pay for a patent, but he sat idly by. He was engaged as a machinist in machine shops. It seems to me it is absurd under such a state of facts to claim that he can go back to 1852, and claim that as the date of his invention. Judge Shepley passed by this defense, and did not think it worth while to consider it, and I will leave it with your Honors without further remark.

Now we come to the question of infringement, the third defense: I will only touch upon, in my argument, the question of this Beyer valve.

Mr. Justice CLIFFORD: Judge Shepley ruled that the defendant used the Richardson invention.?

Mr. FORBES: Yes, sir; we claim that he wrongly so ruled. Defendant's valve was made by Richardson, but we claim that it was not made under his patent. Judge Shepley seemed to have decided this case on this Beyer valve. On page 16 of my brief, I have quoted from Judge Shepley's decision. I will refer you to the page of the brief because I quote there what I wish to refer to. He says.

"From the history of the art as previously given, "and from a comparison of the original with the re-"issued Naylor patent, as well as from the language of "the claim in the reissued patent, it is manifest that if "these claims can be sustained it can only be for the "combination of the described valve, with its over-"hanging downward curved lip, with precisely such "an annular recess surrounding the central chamber "as he describes. *Naylor did not invent the overhanging "downward curved lip or periphery*, nor was he the first "to use *an annular chamber surrounding* the valve seat "into which a portion of the steam is deflected as it "issues between the valve and its seat. His claims "must, therefore, be limited to the combination of the "other elements with *precisely such an annular recess* as "he has described, and operating in the described "manner, so far as such recess, separately or in com-"bination, differed in construction or operation (*if it*

"*did materially differ in those respects*) from those which "had preceded it."

Well, now, what did Judge Shepley have before him, and what did he consider in this case? If we read further from the opinion we find that he left out the Waterman and Green valves and only considered this Beyer valve which has been handed up and is before your Honors. This Beyer patent, to put it in a nutshell, *we claim does not anticipate Naylor's invention because it was not printed nor patented nor published until after Naylor's invention was made.* Now, I think I can convince your Honors that this Beyer patent must be left out of the case; and if it is left out of the case, the sting is drawn from Judge Shepley's opinion. If his premises were wrong his conclusions must fall.

The Chief JUSTICE: Is the Beyer patent an English patent?

MR. FORBES: Yes, sir; they were both English patents; Beyer's patent is printed in the record, at page 41; a cut of the valve head is attached to complainant's brief. Here is a model which I hold up before your Honors (Exhibt Hibbard Beyer model); there is a hood which encompasses the valve, the purpose of which is to form a conduit for the steam, so that the steam will not, by its escape, interfere with the engineer or anyone else.

I have printed in my brief the English law, with reference to the issue of patents, which I will not read, owing to the shortness of our time; I will hand up the book, which is my authority; the title is, "The Law and Practice relating to Letters Patent," for inventions by William Fischer Agnew, London, 1874. The practice in England in brief, is to file a petition for a patent and a provisional specification of the invention sought to be patented; the government causes a statement to be published in the *London Gazette*, that a petition has been filed, the name of the inventor and title of the invention; the provisional specification is not printed; it is not a patent. Beyer's provisional specification was filed April 25, 1863, a com-

munication from abroad, as it is called in England, the real inventor being a professor of engineering at the polytechnic school at Dresden, Germany, who had sent it over to Beyer to have him take out a patent. July 21, 1863 Naylor filed his petition and provisional specification.

I desire to read to your Honors the provisional specification of Naylor, so that you may see what he had invented at that date.

"This invention relates to certain improvements in safety valves, and consists in the employment of valves (when used with levers loaded by dead weights) having *the edges of the valve outside the valve seating cupped, or turned downwards, so that the main body of the steam, as it escapes from the boiler, being directed downwards, strikes against the bottom of a suitable recess, or into a chamber round the pipe leading from the boiler to the valve, and consequently the* RECOILING *action of the steam acts upward against the under surface of the valve as it issues forth into the atmosphere, and by such recoiling action of the steam the valve is assisted in opening*, so as to counteract the resistance of the atmosphere to the issuing steam, which resistance is virtually equal to an extra load on the valve; or the edges of the valves may project horizontally beyond the valve seat, so that the steam, after leaving the valve facing, may act under the projection as it rushes into the atmosphere, virtually acting on a larger valve surface after leaving the boiler, and before its final exit into the atmosphere."

We think that the language used by Naylor shows sufficiently what he was thinking about. It shows that he had made his invention at that time. Then, we wish to state further that the specification which is afterwards filed must be for the same invention as stated in the provisional specification. Your Honors know that in England a specification is filed after the patent is granted. The Government knows very little about the specification; they grant the patent and then the patentee files a specification and runs the risk whether his specification is a good one or not.

Naylor filed his provisional specification as stated, July 21st, and October 16th Beyer received his patent. Can your Honors say that that patent was printed or patented until that date; that is, until three months after Naylor had made his invention, as shown by his preliminary specification? The courts of this country hold that a patent is granted in England, not when it is dated, because it is ante-dated, as of the date of the filing of the provisional specification, but from the time it is sealed. That is the only fair construction of the word patented, as used in our statute. The patent is not granted when it is dated. It is granted when the seal is put on and when it is delivered to the patentee. Now, this Beyer patent was granted three months after Naylor had made his invention and filed his provisional specification, and therefore we claim that the Beyer patent is not an anticipation of Naylor's invention. This point was not raised in the court below; Judge Shepley did not consider it as far as I can learn. It seems to me from what I have read of Judge Shepley's decision that if his attention had been called to this fact his decision would have been different.

The CHIEF JUSTICE: I should say to you that you have already over-reached your hour for sometime.

Mr. FORBES: I am glad your Honor has told me. The explanations required at the beginning caused me to go into the defendant's case so far that I have saved them some labor. Of course I do not want to have any part of their time.

Now with regard to this Beyer patent, there is another point on which I will only say a few words, that is, that there is not sufficient space between the overhanging lip and convex valve seat to retain the steam until it acts expansively.

Mr. Justice STRONG. Is that not a mere difference of degree?

Mr. FORBES: Well, your Honor, that question has bothered me a good deal, and that is why I took the other point in reference to the valve. The steam ac-

cording to the experiments of defendants' witnesses, acts by impinging against the overhanging lip. It does not expand because defendants' witnesses find on the lower lip, there is no pressure; a vacuum, as they say. I have printed my statement regarding this valve very fully in my brief to which I call your Honor's attention.

There is a word that is introduced in the testimony which is very misleading; that is the word "*stricture.*" A "stricture" according to the definition put upon it by the witnesses, is simply some narrow space which confines the steam. Defendants claim that the space between the extended lip and valve seat, through which the steam finally escapes into the atmosphere, is a "stricture." There is no difference between that *stricture* and our *stricture* if the steam is confined. It does not make any difference whether it is variable or whether it is fixed. It is the same if the steam is confined. If the steam can escape from the boiler and relieve the boiler sufficiently, what difference does it make whether the exit is a movable or a fixed stricture, or whether you call it a stricture or an outlet or anything else?

If your Honors please, I have made another point on my brief, which I would like to speak of, and that is about this Exhibit "G," that we have here. Nearly the whole of the testimony was based upon this one exhibit. It was attempted to be shown by it that the chamber and exit in the Naylor valve acted merely as a conduit, and not as a chamber and stricture. There is no allegation in the answer that the invention shown in complainant's patent is inoperative. We claim, therefore, that their testimony ought never to have been admitted in the case; that it has no right here. It may have been introduced to explain the action of our valve. But it was not made according to complainant's patent, and is therefore worthless for that purpose. The reissued patent says (at page 7 of Record):

"My invention also consists in the valve C, constructed

with projecting downward curved lip or periphery, and in the annular chamber D, surrounding the valve-seat, whereby as the spring is compressed by the lifting of the valve, the projecting lip of the valve and the annular recess are available in causing an increased pressure on the valve, and thus overcome the increased resistance of the spring, due to its compression."

Now, if that be true, this Exhibit G has no reference to this case. All defendants' experts say about it is that it represents the Naylor valve with considerable accuracy. (Waters, p. 178, Record). They do not say on what sized boiler it must be placed; and that is very important. The same valve will not operate equally well on two differently sized boilers. A valve which would operate on a boiler carrying 150 pounds pressure would not operate in the same way on a boiler carrying 100 pounds. Each valve must be adapted to its intended use. Nothing was said about these conditions however. If defendants had gone on and made Exhibit G so that the steam would be confined in the chamber as the patent says; as the defendants' own witnesses say it is very easy to do, and as we have shown in these other valves, Exhibits 3, 4, &c., is easy to do, we would not have had any of that testimony. But here they come and put in an exhibit which is made, as they claim, substantially like our valve, and by it they proceed to show that our patent is good for nothing. Becoming afraid of this Exhibit G, and seeing that it was not a true exhibit, defendants went on and made that valve which is before the Chief Justice (Exhibit Hibbard, Naylor's Model), which they say is lineally and exactly or accurately like the drawing in our patent, and that that would not work. Why? Because they simply put it in the hands of workmen, with directions to make it, not as called for by the patent, and as Hibbard says it should have been made to correspond with the patent, but lineally like the drawings of the patent. The valve is tried before the experts who give testimony from hypotheses drawn from it and Exhibit G. Defendants' witness Richardson, says, if there is a

thousandth of an inch difference between the edges of these parts that it makes a difference in the operation of the valve. He also says that it is a very easy thing for him or a mechanic to make it work in practice. Why didn't these men exercise their mechanical skill? Why didn't they simply make this valve as the patent told them to make it instead of making that which they must have expected from the start would not work? How do they know but that if they had made the lip a thousandth of an inch wider it would have worked. Another defect in their experiment. They go and try it *without an escape pipe*. Now, steam escaping through an escape pipe is retarded, and it would be retained in the chamber by that very fact. I understand the effect of an escape pipe on the valve is the same as lessening the area for the exit of the steam; exactly the same thing. They do not put any pipe on, but simply try the valve without, although a flange for the pipe is shown in the patent, and such a pipe is necessary in practise. The spring used made also a great deal of difference in the operation of the valve. All the witnesses say, if you have a weak spring you must have one size of orifice; if a strong spring, another size of orifice. All these things vary with the circumstances of the case, and an ordinary workman could make the changes required (Richardson, pp. 76 and 87.) Now, defendants did not do this, I am sorry to say, nor did they pay any regard to the pressure of steam at which the valve would operate.

I trust I have not wearied your Honors, but I have tried to be as clear in my statement as possible.

I have put in my brief some reflections on the decision of Judge Shepley, which I think are proper to be made, and which I would like to have your Honors read (per p. 34, etc., Brief.)

FRANCIS FORBES,
Of Counsel for Appellant.